
GOODYEAR

5 Street Ecology

Street Trees

Tree Belts

Street trees can be used to serve a variety of ecological and urban design functions. Based on their location, arrangement, and spacing trees can:

- Provide needed shade and filtered light
- Capture and reduce the velocity of stormwater, and provide treatment of runoff from urban landscapes
- Provide carbon sequestration, improving air quality and meeting goals of the City's *Climate Action Plan*
- Provide food and nesting resources for wildlife, such as birds and pollenators
- Create a sense of enclosure that frames, defines, and accentuates spaces
- Add texture, delight, and human scale
- Lend other human health and wellness benefits

Iconic plantings of street trees associate neighborhoods with seasons, and contribute to a unique sense of place. Trees are an ideal form of shade, providing protection on hot summer days while allowing heat and light to penetrate during cold winter months. They are considered to be the lungs of the City and preserving and expanding the street tree system is an important strategy in the *Climate Action Plan*.

They can also calm traffic by narrowing the apparent width of the roadway. Street trees should be used in thoughtful compositions that respect the overall street context, local environment, and adjacent land uses. Trees offer tremendous economic value by making places more attractive and inviting, thus adding to the vitality of commercial areas and to the value of private properties.

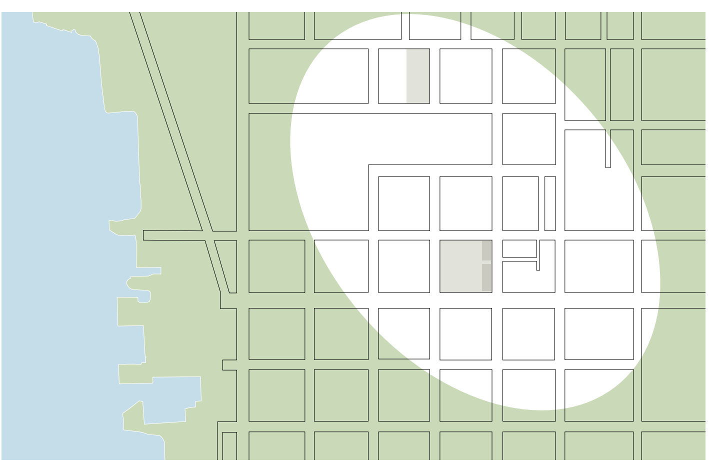
Street trees with robust canopies and root systems also provide stormwater management benefits. Their canopies slow stormwater on its way to drainage systems and their roots filter and absorb stormwater as it soaks into the ground. Street trees also create habitat for urban wildlife through their leaves, seeds, ands structure. An investment in trees as part of street reconstruction projects will lead to a greater realization of benefits over time as trees mature.

Biodiversity

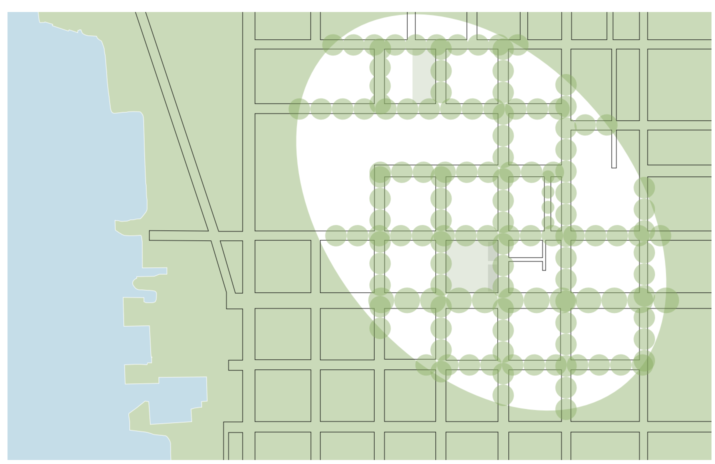
A mixed planting of trees from the approved species list is desired to give each block its own identity and yield a more resilient tree canopy in Downtown Burlington. Diseases, pests, pedestrian and vehicle traffic all pose threats to urban trees. In the early 1900s, Burlington's downtown character was defined by the grandeur of thousands of American Elms. By 1980, nearly all of them had succumbed to Dutch Elm Disease. By planting a diversity of species, the risk of a repeated failure of this magnitude is mitigated.

Snow & Salt

Snow and ice management is critical to maintaining downtown Burlington's accessibility during the winter months. Shovels, plows, and salt, however create a suboptimal environment for growing healthy street trees to maturity. Street tree plantings in downtown Burlington must be designed for maximum resilience in this environment—without compromising on pedestrian safety. Tree guards, which are plow and salt-resilient, will be used to protect trunks from plow and shovel strikes.

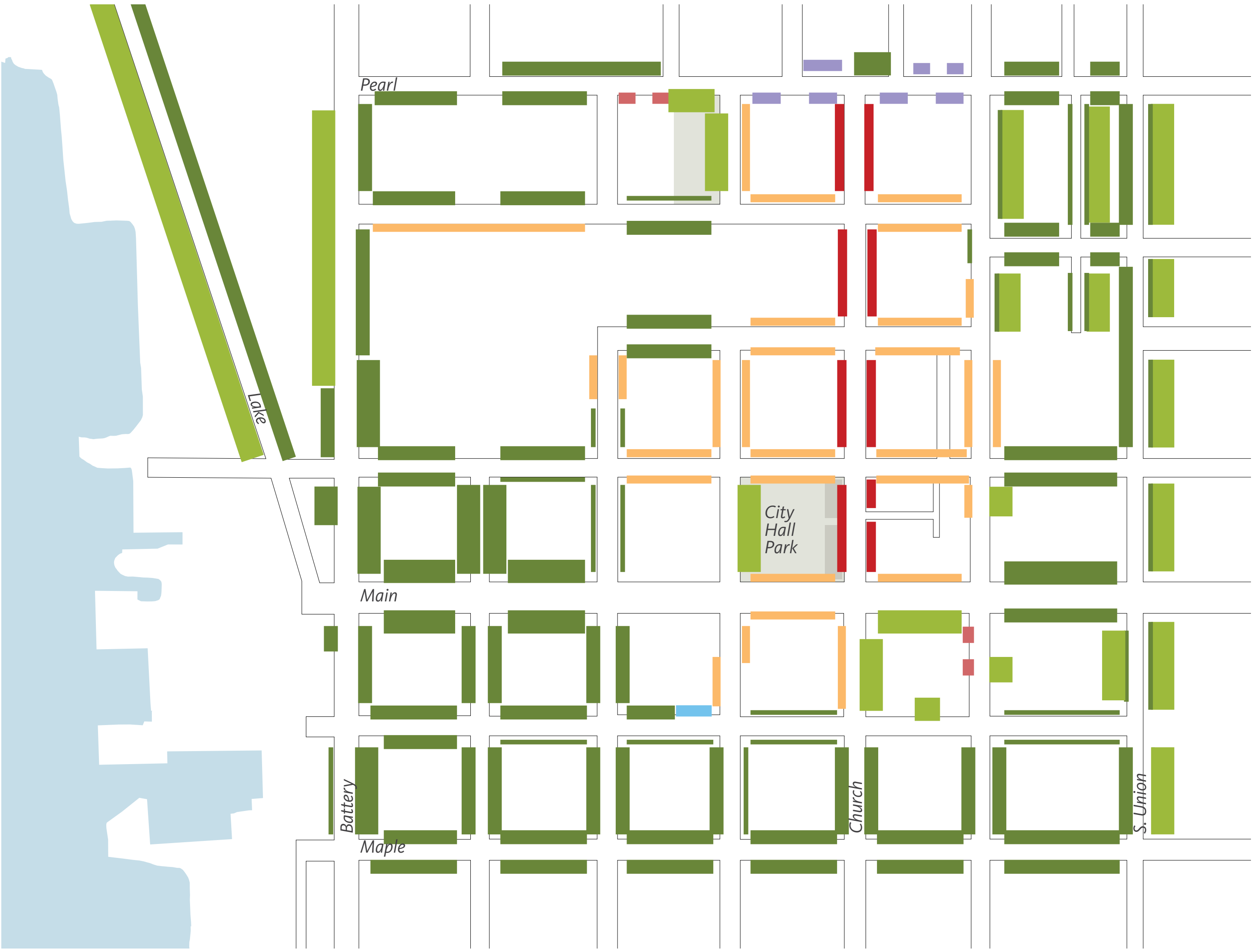


While the area surrounding Burlington is lush and green, canopy coverage is severely limited downtown in areas of high pedestrian activity.



Burlington has the opportunity to invite the canopy back into the downtown. By incorporating green infrastructure and adequate soil volumes which are outlined in these standards, Burlington can weave trees throughout the downtown rights-of-way in ways not previously achievable.

Existing Tree Belt Conditions



Lawn (behind sidewalk/private property)

Broad Green Belt (>12')

Standard Green Belt (5'-12')

Narrow Green Belt (<5')

Granite Tree Belt

Permeable Red Brick Tree Belt

Church Street Brick Tree Pits

Sidewalk Cutout

Garden (in ROW)

The diagram above includes an inventory of the current planting conditions of downtown Burlington's street trees. A detailed description of each of these conditions can be found in *"Street Trees & Tree Belts" on page 24.*

Proposed Tree Belt Conditions

Lawn (behind sidewalk/private property)

Broad Green Belt (>12')

Standard Green Belt (5'-12')

Narrow Green Belt (<5')

Church Street Brick Tree Pits

Permeable Brick Tree Belt (New Type)

** Existing red brick pattern to be used within sidewalk and tree belt areas fronting City Hall on Main and College per Great Streets: Main Street Plan.*

The treebelt pavers should be a matching permeable red brick from the same manufacturer as the one being used for the rest of the treebelt zone.

Tree Belt & Green Belt Typologies

Tree belts can be beautiful, durable, and multi-functional spaces. To make the highest and best use of precious space in the right of way, Burlington will transition many of it's downtown tree belts from concrete or compacted turf to a continuous band of permeable paving. In some residential areas, where pedestrian traffic is lighter and erosion is under control, green belts utilizing turf will remain.

The tree belt buffers pedestrians from traffic and provides a visual amenity for all. In addition to its visual and psychological benefits, this strip between the sidewalk and street provides environmental benefits by absorbing and filtering stormwater runoff, providing shade, reducing the urban heat-island effect, and absorbing carbon dioxide. In Burlington's northern climate, tree belts perform the additional important function of snow storage in winter months.

The width of the tree belt is an important design consideration. At a minimum, tree belts should be six feet wide. Wider belts provide better growing conditions and will result in improved health and vigor of street trees. In general, trees benefit from greater soil volume, a continuous tree belt, or a continuous subsurface soil volume which can be aided by soil cells. In traditional retail areas with on-street parking and higher-intensity pedestrian demands, trees will be planted in prepared beds of structural soil running beneath the sidewalk.

Structural soil is an engineered soil mix that serves the dual function of supporting the pavement and accommodating root growth. This allows a continuous soil volume to be achieved by connecting subsurface planting beds to one another or to nearby landscape areas. In some situations, soil cells utilizing horticultural soil can also be utilized to create the capacity for a tree's root system to grow where the idea tree belt width cannot be achieved.

These healthier growing conditions are easier to achieve in appropriately-sized tree belts. This section provides guidance for the application of the various techniques as illustrated in the *"Proposed Tree Belt Conditions" on page 175*, including:

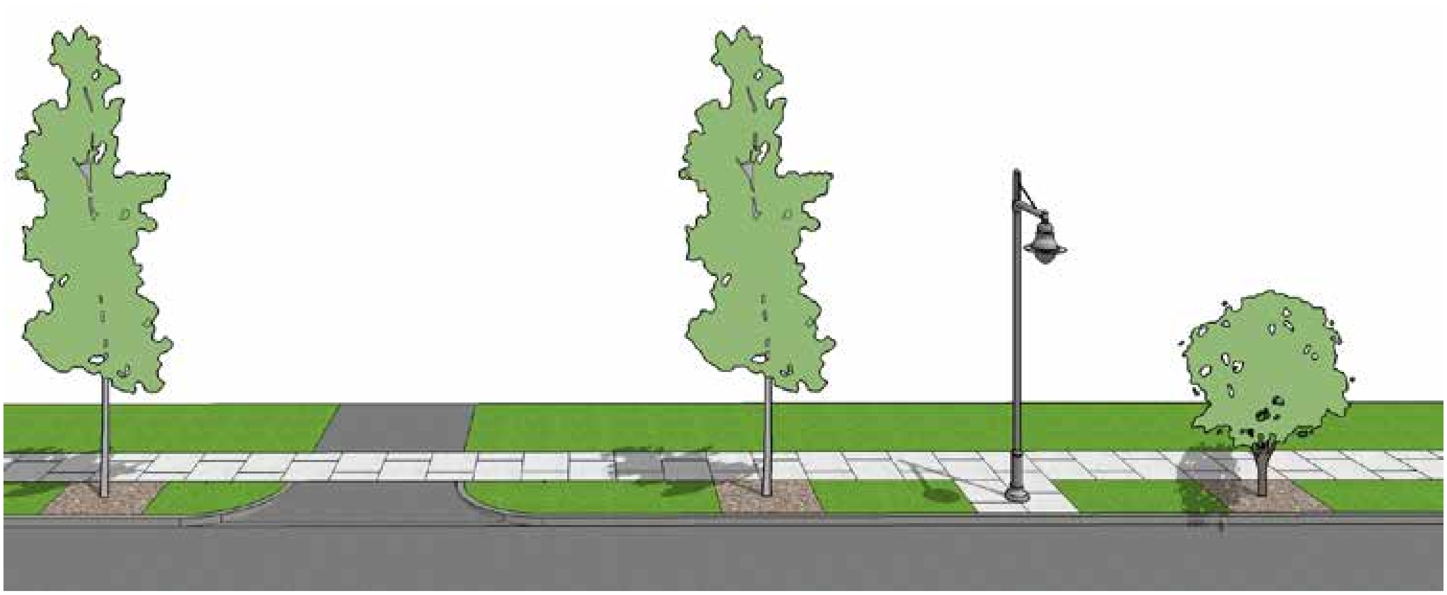
Gray Brick Tree Belt with Permeable Pavers

- 6' Minimum Width, with tree planters or tree grates
- 8' Preffered Width with tree planters or tree grates

Green Belt with Turf

- Lawn (behind the sidewalk/private property)
- Broad Green Belt
- Standard Green Belt
- Narrow Green Belt

For other considerations which affect the placement and treatment of tree belts and green belts, see the *"Element Siting & Considerations" on page 112* for sections regarding Street Trees and Tree Grates and Guards.



BRICK TREE BELT WITH PERMEABLE PAVERS

Description
Permeable Brick Pavers are recommended as the primary surface material for use within the downtown tree belts. Roots and soils are protected from pedestrian traffic by the pavement. Within the newly defined tree belt, street furnishings, café seating, and bicycle parking will sit above a surface that absorbs stormwater and provides uncompacted rooting space for trees below.

Location
- Typically located between the Clear Pedestrian Zone and the Roadway Zone's Parking Lane or Bikeway.
- Continuous across curb-cuts/driveways.
  - At curb-cuts/driveways, impervious pavers of the same color and material and from the same manufacturer as the surrounding tree belt may be used over a concrete base to meet the frequent vehicular loading requirements of these areas.
- Terminates at crosswalk zone before intersection.
- Block corners to be paved with concrete.

Width
6' or 8' depending on conditions and width of Pedestrian Zone in standard cross section. See recommended Street Types on *page 67*.

Materials
Paver specifications: *"Tree Belt Permeable Pavers" on page 277.*

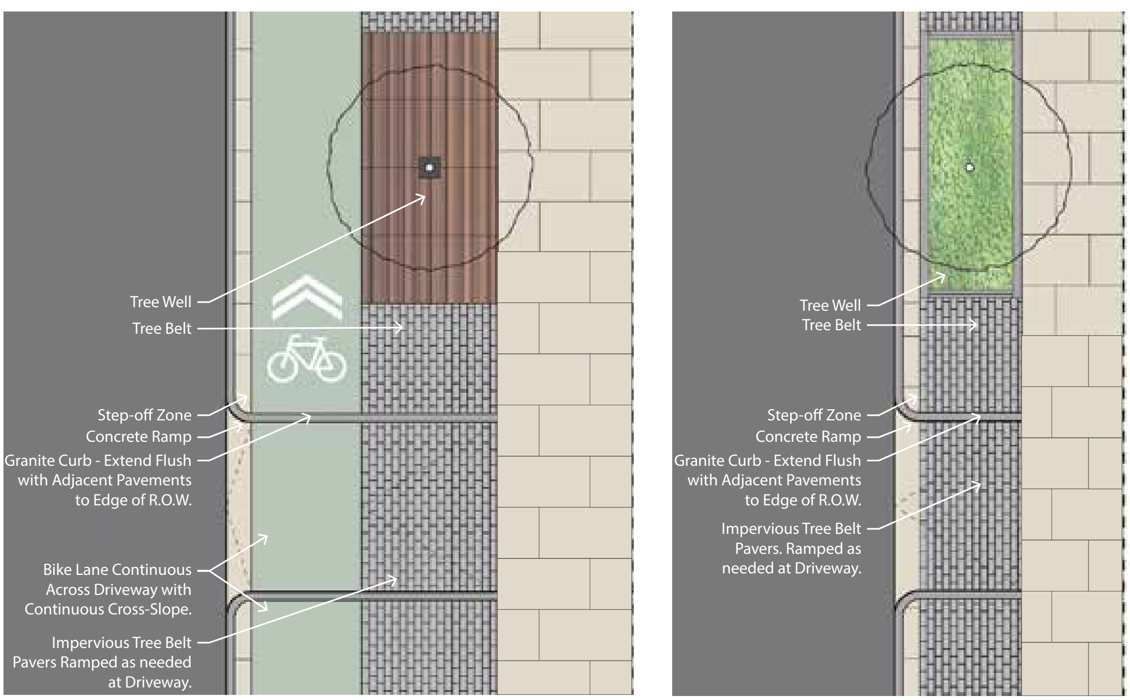
Tree Well Condition
Planted or Tree Grate depending on level of pedestrian activity and width of the Pedestrian Zone. See *page 186* and *page 230* for tree well plantings and *page 307* for tree grate specifications.

Subsurface Conditions
Soil volumes in the tree belt alone may be insufficient to support trees which survive to produce large canopies. Soil cells may be used beneath adjacent pavements to provide required soil volumes to new trees. Structural soils may also be used under sidewalks or where soil cells cannot be used due to limited space or other factors. Horticultural soils are to be used as the medium in soil cells, planted tree wells, and in tree wells covered by tree grates.

Grading
Grading in the tree belt is used to direct surface stormwater flow. In areas where tree wells are planted and open, the grading of the brick will crease at the center, directing water parallel to the curb and into the tree well. Where tree grates are used, grading will pitch water toward the curb. In all cases, ADA standards for accessibility must be met as a top priority.

Maintenance
Permeable paving allows stormwater to soak into the ground while debris is captured within the system. Paver joints will need to be cleaned quarterly to maintain the pavement system's permeability. The City of Burlington owns and operates equipment for this purpose and will set the schedule for pavement cleaning.

Treebelt at Driveway Entrance



Left: Curb cut at 8' treebelt & protected bike lane

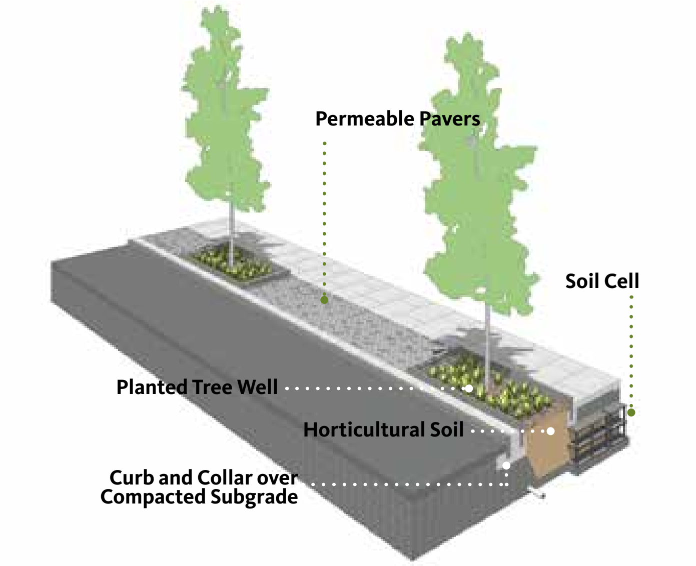
Right: Curb cut at 6' tree belt

6' Wide Brick Tree Belts

Tree Belt with Planted Tree Wells

This is the most common condition anticipated to be applied within the downtown. This should be applied in commercial and mixed use areas with moderate pedestrian activity and where the preferred dimensions for the Pedestrian Zone for cross sections can be met. Trees in this condition are surrounded by salt-resilient plantings in a bed that infiltrates stormwater. Tree wells are typically 12' long, and are framed by 6” wide granite curbs on the sides parallel to the street with metal tree fencing on the perpendicular sides. Small, medium, and large tree species are appropriate in this condition.

See additional tree planting details in *"Tree Planting at Tree Well" on page 185*.

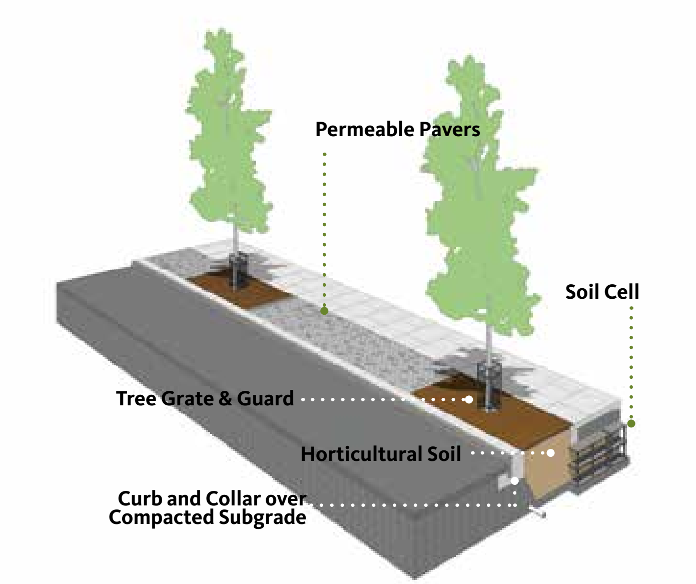


6' wide tree belt utilizing permeable pavers and planted tree wells.

Tree Belt with Tree Grate

This should be applied in commercial and mixed use areas with moderate to high pedestrian activity, frequent restaurant/ retail destinations, and adjacent to loading zones. This may also be used for street types with a preferred Tree Belt/Furnishing Zone dimension of 6', but where the preferred or minimum dimensions for other Pedestrian Zone elements cannot be met due to encroachments or other constraints. Tree roots in this condition are protected by tree grates, and tree trunks by tree guards. Tree grates are typically 12' long, and flush with other pavements. Small, medium, and large tree species are appropriate in this condition.

See additional tree planting details in *"Tree Planting at Tree Grate" on page 184*.



6' wide tree belt utilizing permeable pavers and tree grates and guards.

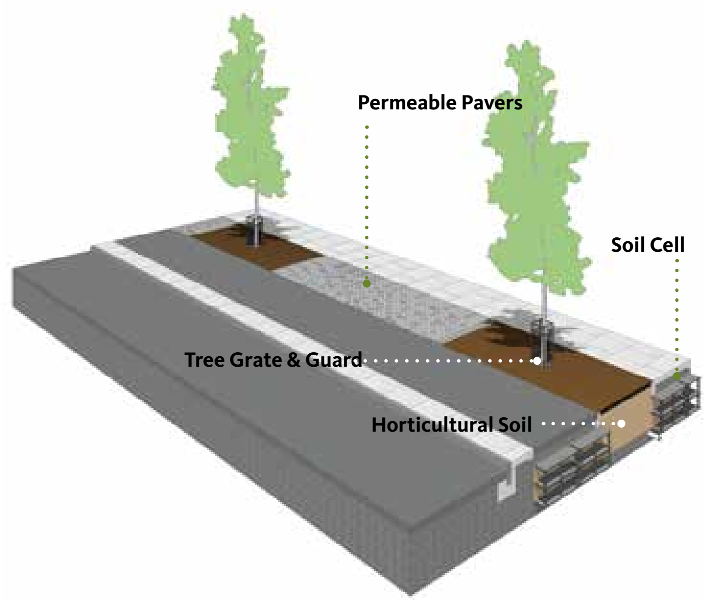
8' Wide Brick Tree Belts

8' wide tree belt utilizing permeable pavers and planted tree wells.

Tree Belt with Planted Tree Wells

This should be applied in commercial and mixed use areas with moderate pedestrian activity and where the preferred dimensions for the Pedestrian Zone for cross sections can be met. This may be installed adjacent to a Buffer Zone or a Protected Bike Facility at the sidewalk grade, such as the western blocks of Main Street. Trees in this condition are surrounded by salt-resilient plantings in a bed that infiltrates stormwater. Tree wells are typically 16' long, and are framed by 6" wide granite curbs on the sides parallel to the street with metal tree fencing on the perpendicular sides. Only large tree species are appropriate in this condition.

See additional tree planting details in *"Tree Planting at Tree Well" on page 185*.



8' wide tree belt utilizing permeable pavers and tree grates and guards.

Tree Belt with Tree Grate

This should be applied in commercial and mixed use areas with moderate to high pedestrian activity, frequent restaurant/ retail destinations, and adjacent to loading zones. This may also be used for street types with a preferred Tree Belt/Furnishing Zone dimension of 8', but where the preferred or minimum dimensions for other Pedestrian Zone elements cannot be met due to encroachments or other constraints. This may be installed adjacent to a Buffer Zone or a Protected Bike Facility at the sidewalk grade, such as the block of Main Street adjacent to City Hall Park. Tree roots in this condition are protected by tree grates, and tree trunks by tree guards. Tree grates are typically 16' long, and flush with other pavements. Only large tree species are appropriate in this condition.

See additional tree planting details in *"Tree Planting at Tree Grate" on page 184*.

GREEN BELT WITH TURF

Description

Green belts planted with turf are the most common existing tree planting condition within the downtown; as such, many of the busiest streets and widest setback areas in downtown utilize this condition. In some instances, large, open soil volumes exist to support tree growth. If appropriately maintained, trees may survive in this condition to produce large canopies. However, in other locations, the width of the green belt can limit trees' ability to reach a mature size, or levels of pedestrian activity may damage roots and lead to soil compaction. Green belts with uncompacted soils provide some level of stormwater infiltration.

Location

- Typically located between the Clear Pedestrian Zone and the Roadway Zone's Parking Lane or Bikeway.
- Terminates at intersections.

Width

5'–8'+, depending on conditions and width of Pedestrian Zone in standard cross section. See recommended Street Types on *page 67*.

Materials

Standard VTrans Urban Lawn Mix in *Appendix section A-6*

Tree Well Condition

Mulch around roots, turf between plantings. See additional tree planting details in *"Tree Planting in Turf Green belts & Lawns" on page 183*.

Subsurface Conditions

Depending on width of green belt, soil volumes may be sufficient to support trees which survive to produce large canopies. However, for Standard and Narrow Green Belt conditions, the soil volumes in the tree belt alone may be insufficient. Soil cells may be used beneath adjacent pavements to provide required soil volumes to new trees. Structural soils may also be used under sidewalks or where soil cells cannot be used due to limited space or other factors. Horticultural soils are to be used as the medium in soil cells and unpaved portions of the green belt.

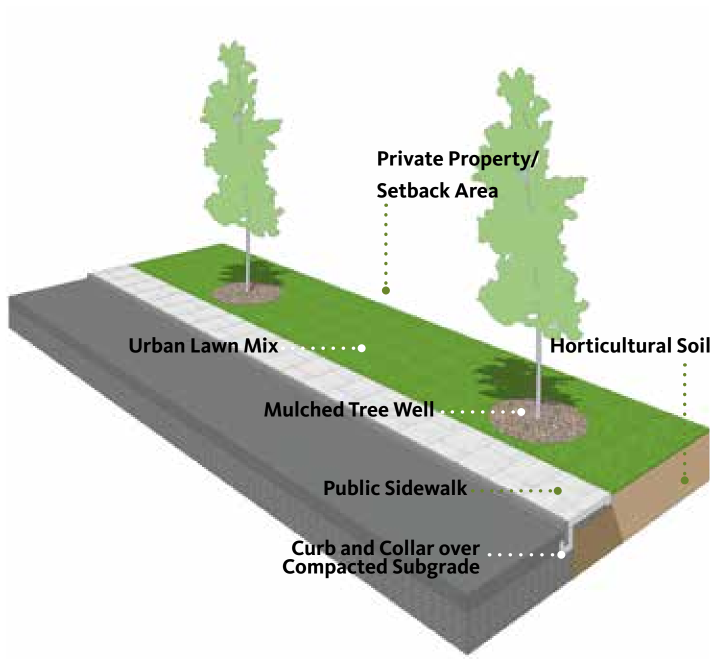
Maintenance

These green belt conditions should be monitored. If evidence appears of compaction and erosion due to the level of pedestrian activity, a pavered tree belt solution should be considered to protect tree roots and avoid excessive stormwater runoff and channelization.

Green Belt Types

Lawn (behind sidewalk/on Private Property)

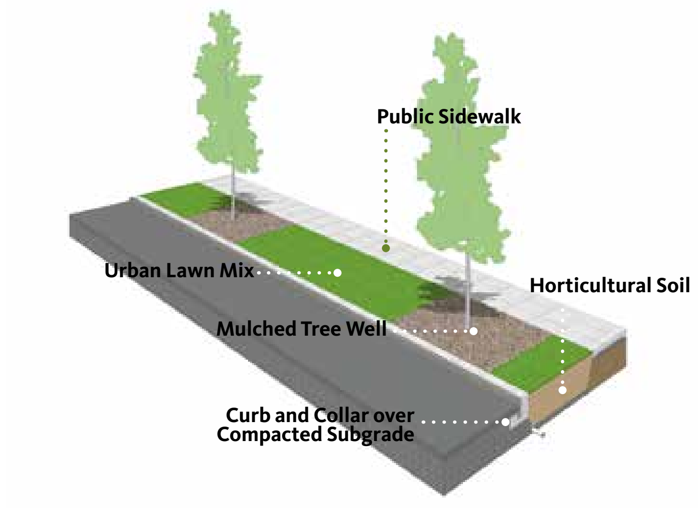
There are several locations within downtown where trees on private property function as part of the streetscape, and provide the benefits of street trees. As deemed appropriate by the City Arborist, this condition should remain until redevelopment prompts the installation of a standard tree belt. In these conditions, no soil cells or structural soils are necessary as the large, open soil volumes available on the private property or within setbacks are generally sufficient to produce trees with large canopies. New trees can be planted within lawn areas behind the sidewalk when there is no ability to locate trees within the public ROW, or when it is not anticipated that the adjacent property will be redeveloped within the next 20–30 years. Small, medium, and large tree species are suitable for planting in these conditions.



Trees located behind the sidewalk on private property or in setback areas providing benefit of street tree to public ROW.

Broad Green Belt

This condition currently hosts trees planted along some of the busiest streets and widest sidewalk setbacks in Burlington. As deemed appropriate by the City Arborist, this condition may remain in selected areas in order to preserve large, healthy trees. However, this condition is prone to compaction and erosion in areas with adjacent on-street parking and/or high levels of pedestrian activity. This condition should be replaced with the standard tree belt as blocks are redeveloped when trees are in struggling condition or where preservation of the existing green belt is infeasible. Where these green belts are more than 8' wide, large, open soil volumes are often sufficient to support trees which survive to produce large canopies. Soil cells may be used beneath pavements if necessary to provide required soil volumes to new trees. Small, medium, and large tree species are suitable for planting in these conditions.



Broad green belt condition with 8'+ of turf between the curb and sidewalk.

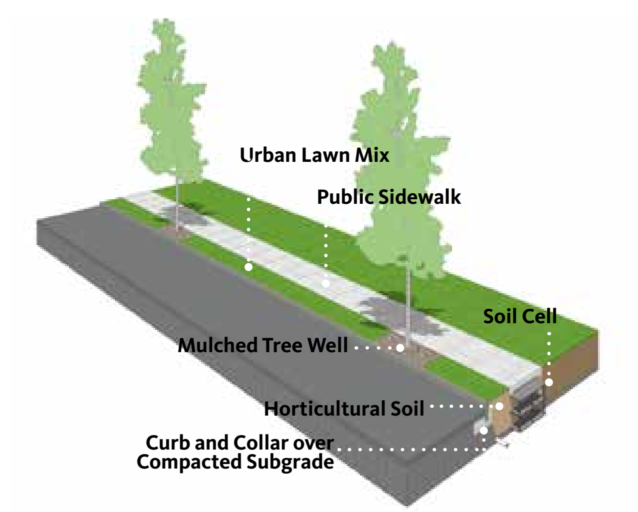
Standard Green Belt

This is the historic green belt condition in downtown. However, this condition is only desirable on primarily residential streets with low foot traffic and on blocks with slopes of less than 5%. Therefore, this condition may remain in selected areas as indicated in the Proposed Tree Belt Condition diagram. In order to protect against compaction and erosion that can damage roots and turf, an 18-inch "carriage walk" should be installed along the curb line within the green belt where possible. Soil cells may be utilized beneath pavements if needed to provide required soil volumes for new trees. Otherwise, horticultural soils should be used in unpaved portions of the green belt at a minimum depth of 36". Small, medium, and large tree species are suitable for planting in these conditions.

Standard green belt condition with an 18" "carriage walk" adjacent to the curb to protect tree roots and turf from erosion from adjacent on-street parking.

Narrow Tree Belt

This tree belt type exists where a narrow ROW accommodates only a slender green belt. In the future, this condition is only appropriate on primarily residential streets where there is already a narrow/substandard green belt and with low pedestrian traffic. In this condition, soil volumes in the green belt alone are insufficient to support trees which survive to produce large tree canopies. Soil cells or root trenches shall be used underneath pavement to provide required soil volumes for new trees. A root trench is a 12" wide × 18" deep (min.) trench filled with uncompacted horticultural soil that connects a tree well to nearby soils. Root trenches may pass beneath sidewalks and through retaining walls or other obstacles and must provide unobstructed root access to soils appropriate for supporting healthy tree growth. Only small tree species are appropriate for planting in these conditions.



Narrow green belt condition with soil cells to support small tree species.

Tree Planting Details

TREE INSTALLATION GUIDELINES

This section includes guidelines for the installation of new street trees. The following are general installation guidelines that apply to all tree plantings. Additional details for specific tree belt planting conditions can be found on the following pages.

- Only plant one row of trees per each side of street
- Select from species identified in these standards; ensure a warranty of at least 1 year post installation/substantial project completion/project acceptance
- Coordinate with utility owners to determine whether Soil Cells or Structural Soils are preferred directly over utility lines. Ensure locations of utilities have been identified; call DigSafe 811 to verify.
- Prepare subsurface for tree installation.

Soils
- Place Tree on (85% maximum) compacted Setting Mound made of Horticultural Soil, assuming native soils are not appropriate.
- If suitable soils exist nearby, these may be accessed to provide required soil volumes.
- Provide minimum volume soil for each tree based on Species List provided in this document.
- Soils beneath paved surfaces must be protected from compaction with soil cells.
- Structural soils are permitted in areas where soil cells cannot fit or are otherwise impractical. (Structural soils can only make up a max 20% of total soil volume for each tree.)
- Install Soil Cells and Structural Soil per manufacturer-provided specifications.
- Soil depth minimum is 3' with variations allowable at building/utility conflicts.
- To access nearby soils across impervious subgrades, connect them to the Treebelt using a 2' W × 3' D min. channel of Soil Cells (min. 1 per tree).

Drainage
- Prepare subgrade for drainage as site conditions allow.
- On sites suitable for infiltration, provide Gravel Drainage Layer on subgrade.
- Use Geotextile Fabric to Protect Gravel Drainage Layer from filling with soils.
- Provide perforated Soil Drainage Pipe connected to city stormwater or combined sewer.

Root Barrier
- Provide Root Barriers to direct roots away from adjacent pavements, curbs, underground utilities, and other sensitive underground features.

Irrigation/Aeration
- Provide Irrigation/Aeration System for hand-watering and gas exchange.
- Set inlet at grade. Protect the opening from debris.
- Automatic irrigation systems are permitted, not required.
- Consider using harvested rainwater to supply irrigation systems.

Tree
- Remove all burlap, wire baskets, nails, etc. from the root ball.
- Set tree plumb.
- Set top of root flare at top of soil profile. Do not bury the root flare.

Tree Anchor
- Anchor tree with subgrade tree anchor system with pre-approved products or others approved by the City Arborist.
- Stake trees with less than 3" caliper. Generally, larger trees do not require staking unless they are in a very windy area.

Pollutants
- Roadway runoff is permitted in stormwater planters.
- Roadway runoff is **NOT** permitted in sidewalk tree wells.

Approved Products

These products are pre-approved to meet tree planting requirements in the downtown ROW. Substitute products offering equal performance may be used if approved by the City Arborist.

Root Barrier
- ReRoot Linear Ribbed Root Barrier by GreenBlue Urban
- RootStop by GreenBlue Urban
- Root Barrier by Deeproot
- EP Series Root Barriers by NDS
- Platipus Root Barrier by Platipus

Irrigation/Aeration System Components:
- RootRain ArborVent & RootRain Pipe—by GreenBlue Urban
- RootRain Precinct & RootRain Pipe—by GreenBlue Urban
- RootRain Urban—by GreenBlue Urban (Turf Treebelt Only)
- RootRain Civic—by GreenBlue Urban (Turf Treebelt Only)
- RWS Root Watering System 36" Depth—by Rain Bird

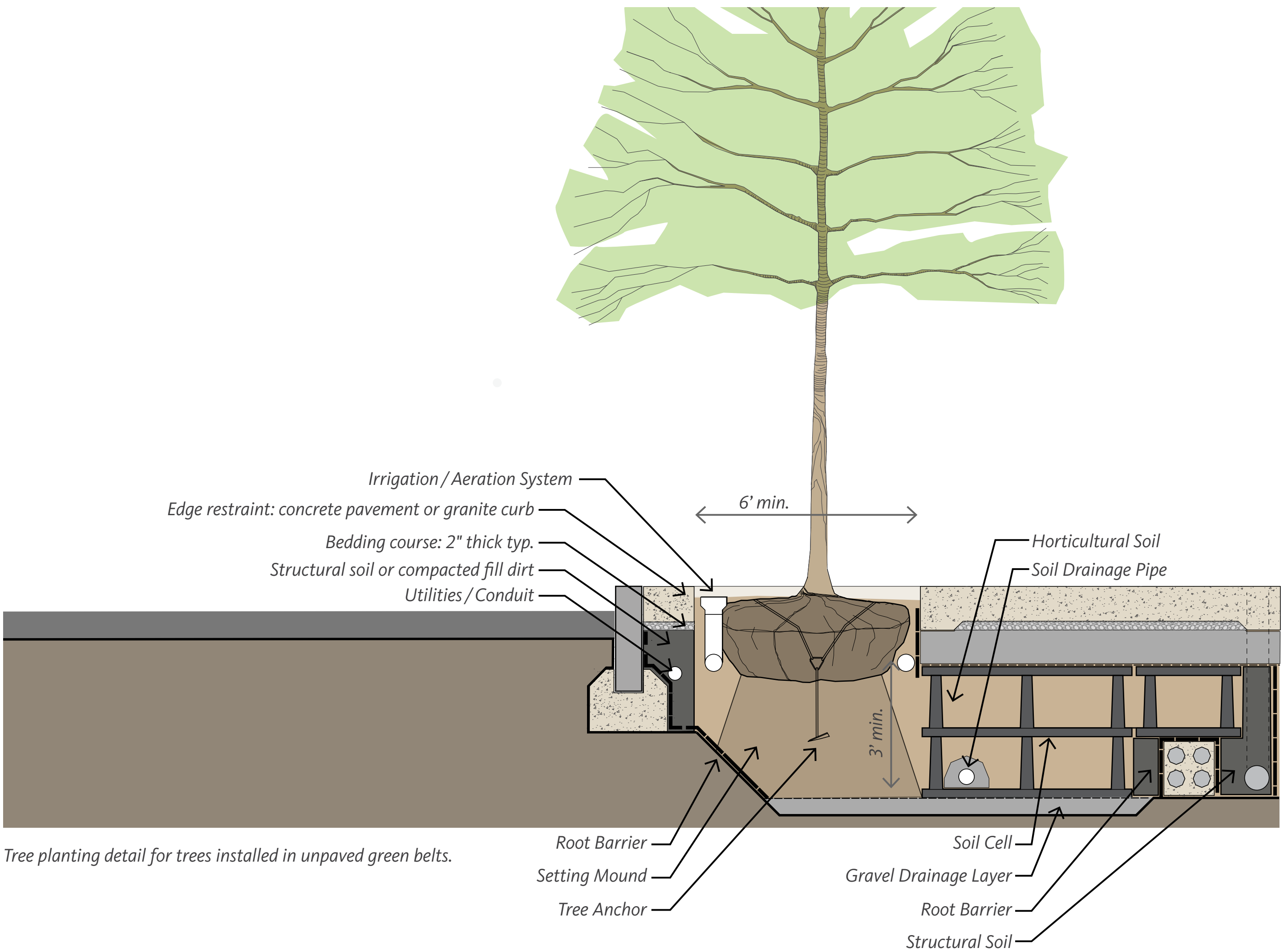
Tree Anchor
- ArborGuy—by GreenBlue Urban
- Root Ball System—by Duckbill Earth Anchors
- Strap Rootball Fixing System—By Platipus

TREE PLANTING IN TURF GREEN BELTS & LAWNS

Trees planted within green belts shall follow all *"Tree Installation Guidelines" on page 182*, as well as these additional details.

Mulch

- Mulch a square area with the tree in its center at a 2" depth.
- The mulched area must cover the full width of the green belt.
- In Lawn and 8'+ Broad Green Belt areas, mulch a circular area with a 4' radius centered on the trunk.
- Bare soil should be left at the base of the tree to avoid trunk suffocation or rot.
- Do not sod or seed within the mulch area.
- Weed-prevention fabrics and geotextiles are not permitted.



Tree planting detail for trees installed in unpaved green belts.

TREE PLANTING AT TREE GRATE

Trees planted within green belts shall follow all *"Tree Installation Guidelines" on page 182*, as well as these additional details.

Soils

- Soils are depressed 3" below the adjacent pavement grade, and 4–6" below the underside of the tree grate.

Tree Anchor

- Anchor to tree guard.

Tree Guard

- Install Tree Guards for all trees planted in tree grate condition.
- Adjust guard in accordance with tree growth to avoid metal coming in contact with bark. Remove at the discretion of the City Arborist, when caliper is of sufficient size.

Tree Grate

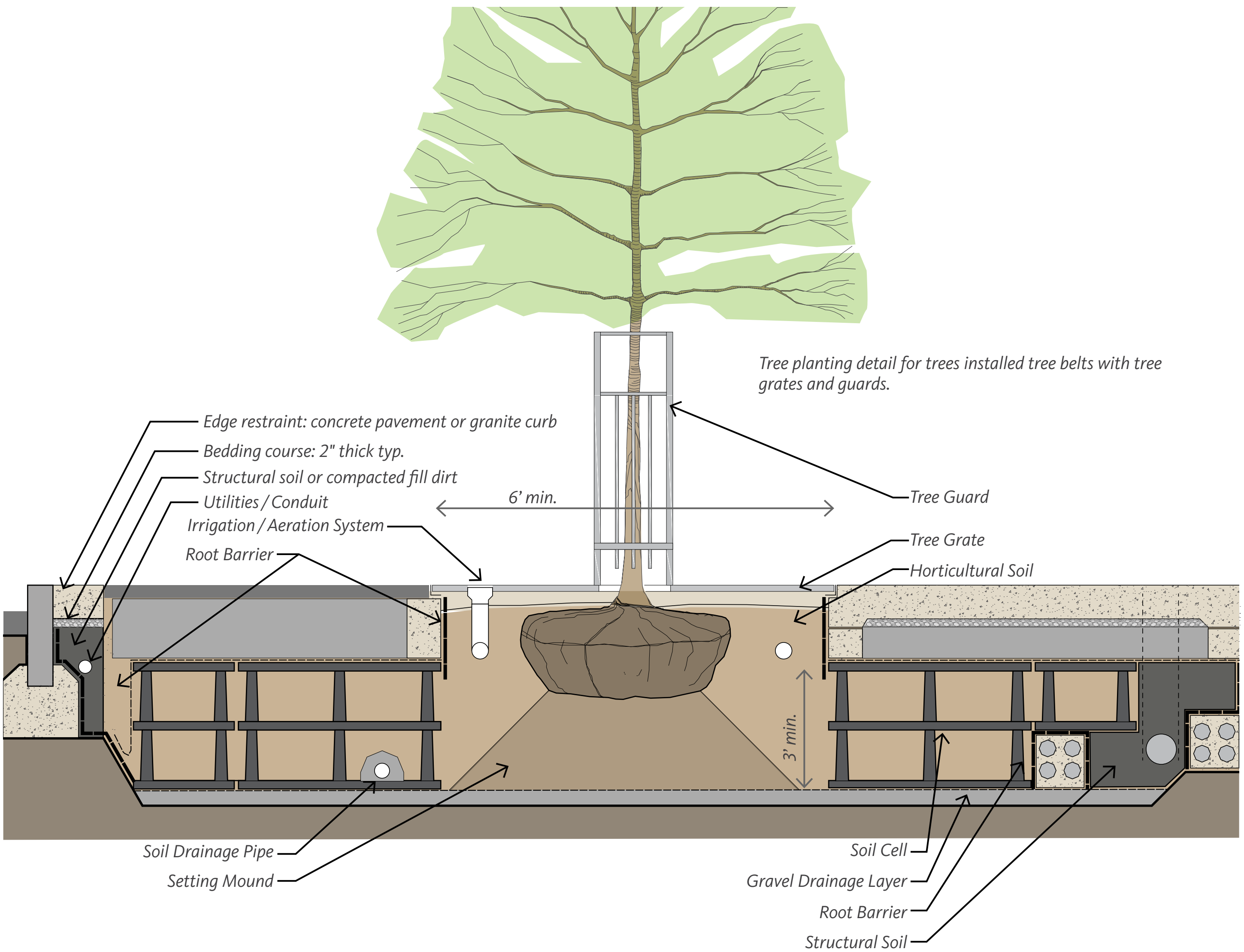
- Tree Grate width must match Tree Belt/Furnishing Zone width.
- Tree grate minimum length is twice the tree grate width. (6' × 12', 8' × 16', etc.)
- Tree grate openings must be expanded over time to accommodate the tree's trunk without scarring it.
- Tree grate shall be level with sidewalk per ADA requirements.

Groundcover

- Option: plant Sedum Blend listed in this document to cover soil surface under grate.

Mulch

- Mulch at a 2" depth to cover entire soil surface under grate.
- Bare soil should be left at the base of the tree to avoid trunk suffocation or rot.
- Weed prevention fabrics and geotextiles are not permitted.



Tree planting detail for trees installed tree belts with tree grates and guards.

TREE PLANTING AT TREE WELL

Trees planted within green belts shall follow all *"Tree Installation Guidelines" on page 182*, as well as these additional details.

Groundcover

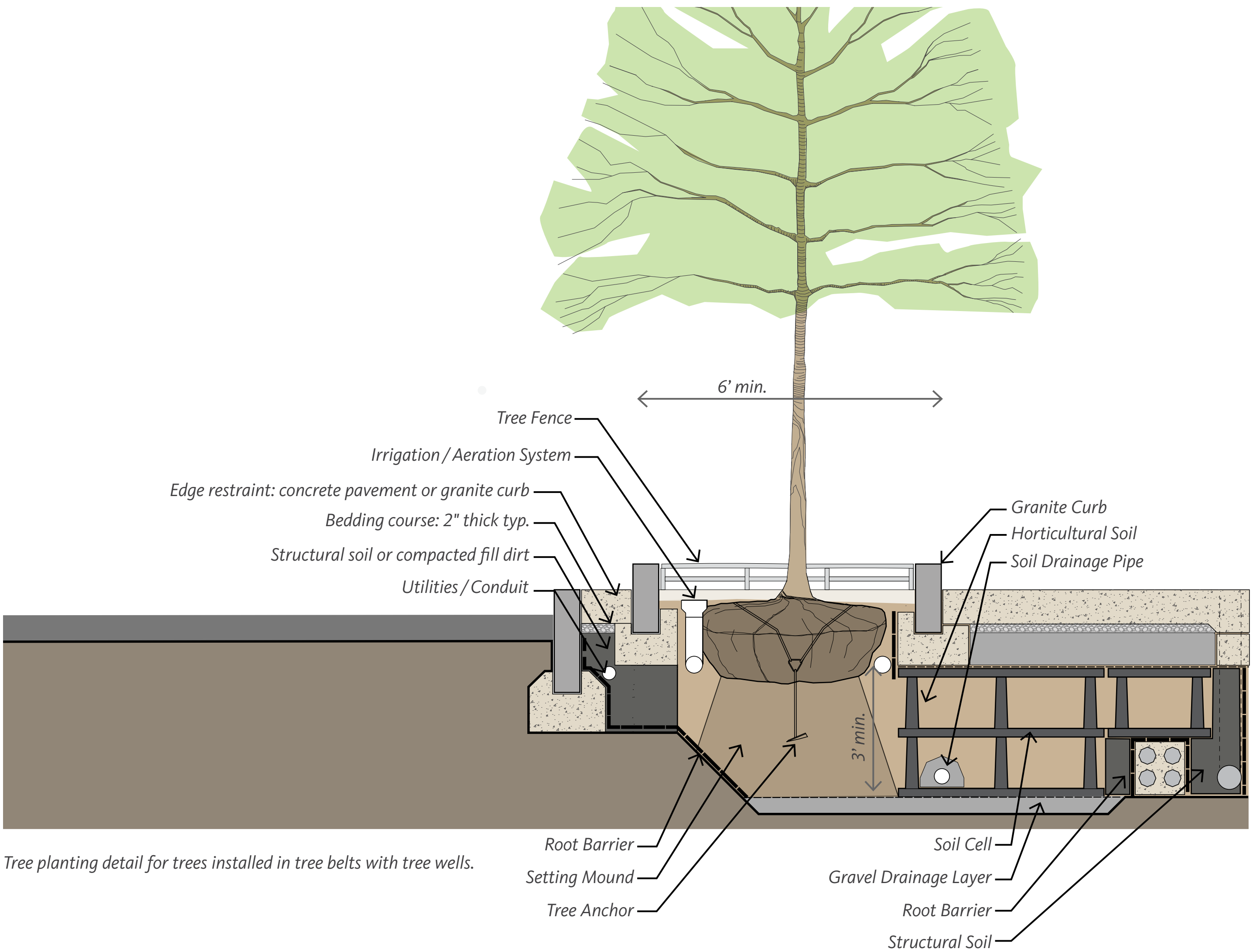
- Plant Groundcover to cover the soils beyond the rootball.
- Select Groundcover species from the recommended list in this document.

Mulch

- Option: Mulch at a 2" depth to cover entire soil surface within tree well.
- Bare soil should be left at the base of the tree to avoid trunk suffocation or rot.
- Weed prevention fabrics and geotextiles are not permitted.

Reference

See *"Tree Well Curb & Fence Details" on page 186*.



Tree planting detail for trees installed in tree belts with tree wells.

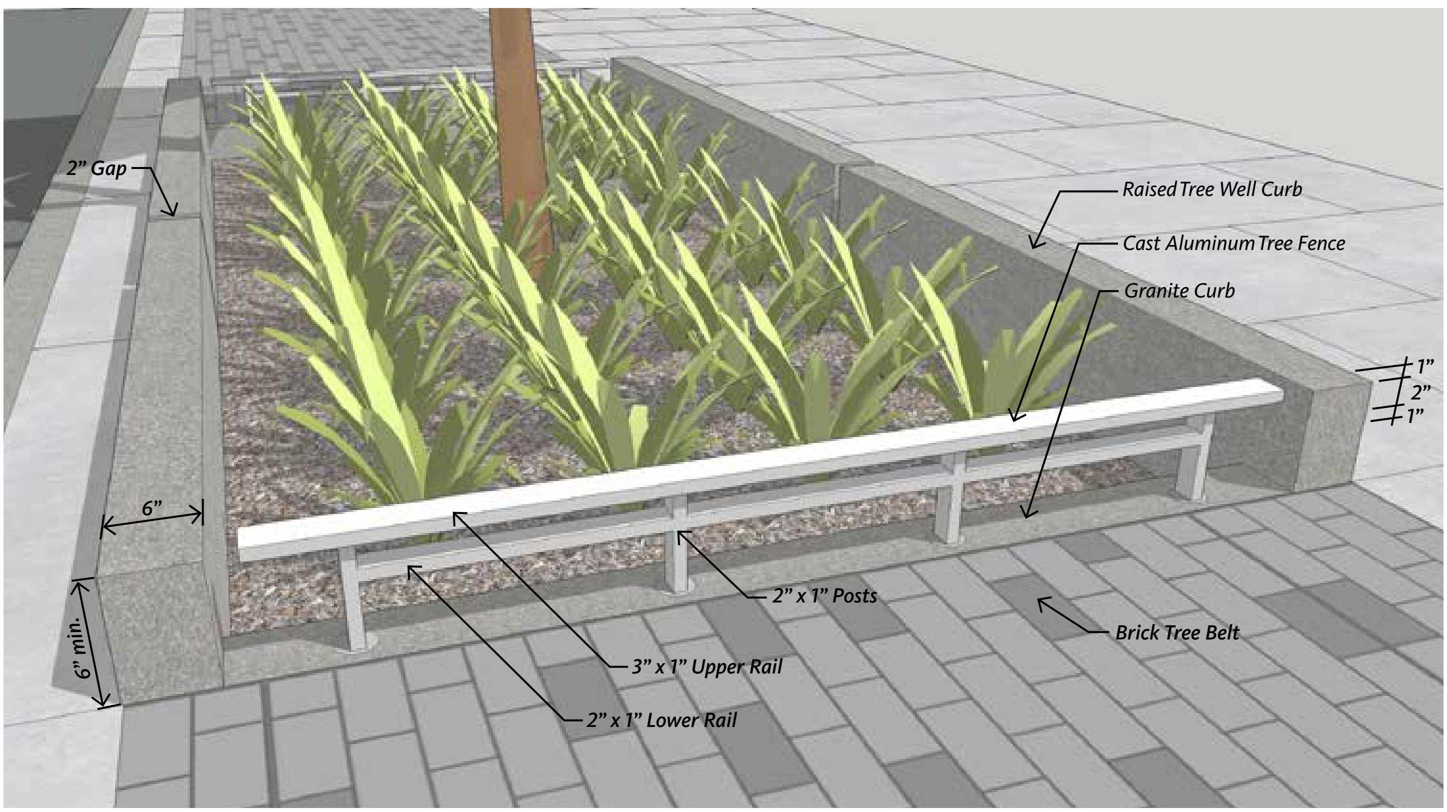
TREE WELL CURB & FENCE DETAILS

Granite Curb

- Granite Curbs shall frame all edges of open tree wells that are within brick tree belts.
- Curbs parallel to the street shall have a minimum 6" reveal above adjacent pavement surfaces. Curbs perpendicular to the street shall be flush with adjacent pavement surfaces to allow stormwater infiltration and overflow. Slope with grade as site conditions allow.
- Granite shall match nearby street curbs as closely as practical in stone source & quality.
- Curbs shall be 6" deep, and have a sawn, thermal finish.
- Curbs shall be set in concrete collars, designed to support them and hold them in place through freeze-thaw cycles and impacts from sidewalk plows/utility vehicles.
- Curb collars shall not be visible. Collars must sit 3" min. below horticultural soil grade in beds. Collars must allow adjacent surface pavements to meet the face of the curb.
- One 2" gap may be cut for every 36" (linear) of raised curb to allow stormwater infiltration from adjacent pavements.

Metal Fence

- Tree Well Fences shall be set into flush portions of the Tree Well Granite Curbs with a weather-resistant non-shrink grout. Posts shall extend into curb a minimum of 6".
- Fences shall be made of Cast Aluminum, appropriate for outdoor use, with a minimum 50% recycled content.
- Aluminum Fences shall be Hot Dip Galvanized and finished with Gray Aluminum RAL 7007 Powdercoat.
- Aluminum Fence posts shall be 2" × 1". Aluminum Fence upper rail shall be 3" W × 1" H, and lower rail shall be 2" W × 1"H.
- Align posts with center line of supporting curb. Center rails on posts. Rails shall match the slope of their supporting curbs.
- The upper rail shall be flush with adjacent raised granite curbs on both ends. The lower rail shall be set 3" o.c. below the top rail.
- Weld all post/rail connections & grind smooth.
- Treat metals to minimize corrosion where they are in contact with grout.



Detail for granite curbs and metal fencing to be installed around planted tree wells in brick tree belts.

PERMEABLE PAVER INSTALLATION

Design & Performance

- Permeable pavement systems are complex and must be designed by a licensed landscape architect or civil engineer on a site-specific basis.
- The diagram provided below is conceptual only and is not intended for use as a construction document.
- Refer to manufacturers for installation and maintenance requirements of all products. Modifications to typical details may be necessary based on site conditions.
- All permeable pavements in the ROW must support AASHTO H-20 loading.
- Where permeable pavers are installed over soil cells or structural soils, coordinate the design of these systems in consultation with their respective manufacturers.
- Permeable paver systems must provide ADA accessibility.
- In constrained sidewalk conditions when a tree belt is located directly adjacent to the curb—no 12-inch step-off zone—a 2-paver deep soldier pattern should be used to frame the running bond between the curb and the parallel pavers (see Figure 4 on page 188).

Subgrade

- Typically, permeable paver subgrade should be designed to allow stormwater infiltration into the soils below. No geotextile should be used to maximize the long-term effectiveness of the system. If geotextile is deterimined to be necessary, the product must be non-woven.
- On some infiltration this may be inappropriate due to soil type, subsoil/geologic conditions, or conflicts with underground structures, etc. On sites where infiltration is inappropriate use an impermeable liner to prevent infiltration.
- Where impermeable liners are used beneath permeable pavers, drainage pipes must be provided to drain all storm water into the storm sewer system. Coordinate subsoil drainage design and storm sewer connection with Burlington Department of Public Works.

Aggregates

- Do not use sand, stone dust, or stone screenings within the paving system.
- Filler stone must be #8 stone, and must either be from a manufacturer who distributes stone for this express purpose, or must be thoroughly washed and show a sieve analysis of no more than 1% passing a No. 200 sieve.

Base & Sub-base

- Sub-base may rest directly on subgrade or on Soil Cells/ Structural Soils.
- Sub-base depth will vary based on expected loads.
- Where Sub-base rests directly on Soil Cells/Structural Soils, a geotextile layer will be necessary to maintain separation between the Sub-base and and the soils below.
- Compact Base & Sub-base materials in minimum 6” lifts.
- Geogrid Fabric may be required for additional reinforcement and ground stabilization.

Paver Joints & Bedding Course

- Use only washed aggregates without fines in Paver Joints & Bedding Course.

Permeable Pavers

- Consider paver durability and safety when selecting which standard pavers are appropriate to use in the ROW.

Edge Restraint

- Permeable Pavers in the downtown ROW shall be contained by concrete pavement or granite curbs on all sides

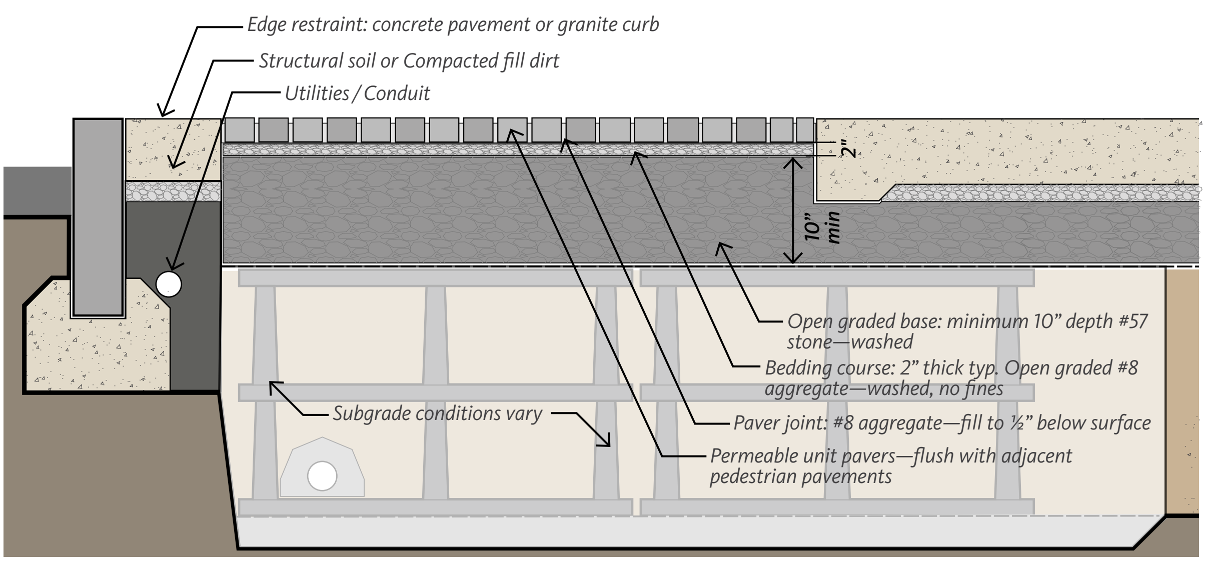


Figure 3: *Standard Tree Belt with 12" step-off zone*

Standard Tree Belt configuration is composed of 6' or 8' wide paver band with a 12" concrete step-off zone adjacent to granite curb. Where possible, it is encouraged that utilities be accomodated under step-off zone.

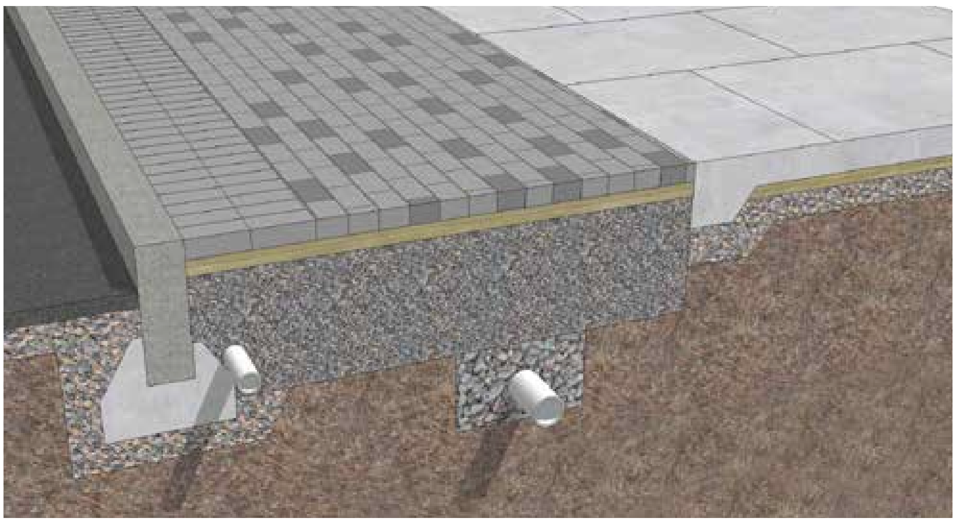


Figure 4: *Tree Belt adjacent to curb without 12" step-off zone*

In constrained sidewalk conditions when a tree belt is located directly adjacent to the curb—without a 12-inch step-off zone, as illustrated in Figure 3—a 2-paver deep soldier pattern should be used to frame the running bond between the curb and the parallel pavers.

Figure 5: *Tree Belt adjacent to curb with Soil Cell condition near tree well with tree grate*

When soil cells are needed to achieve required planting soil volume, soil cells should be held back 12" from back of curb to allow for utilities. Structural soil or compacted fill dirt should be used in this 12" band.

Tree Protection

Tree Protection Zone (TPZ)

- Trees within the ROW may not be removed without the consent of the City Arborist and are to be protected from injury or damage during construction.
- Designate trees to be protected from construction impacts in cooperation with the City Arborist.
- Establish a tree protection zone to protect trees within 25' of construction/demolition work (including utility digging and trenching).
- In open lawn areas and beds, TPZs shall have a minimum 1' radius, centered on the protected tree, for every 1" of trunk DBH.
- In Treebelts, extend the TPZ in each direction at a minimum length of 1' for every 1" of DBH at the full width of the treebelt or until an impermeable paved surface is reached.
- Where extreme site constraints or obstacles restrict the TPZ to a smaller area: Determine whether the tree is a good candidate for preservation with the city arborist. Trees with damage to over <30% of their root systems may be severely compromised. Where site workers must enter a TPZ, protect the soil with a 6" thick layer of shredded bark or wood chip mulch for the duration of the disturbance period.
- Within the TPZ, Vehicular Traffic is strictly prohibited.
- Within the TPZ, storage of tools , equipment, soil, or construction materials is strictly prohibited.

Pavement Removal

- Where existing pavement is to be removed within the root zone of a protected tree, leave pavement in place as long as possible.
- Review removal technique with project arborist or project landscape architect.
- Once pavement has been removed within the root zone of a protected tree, vehicular traffic over the roots is prohibited without consultation with and consent from the City Arborist.

Tree Protection Fence

- Install a Tree Protection Fence at the boundary of each TPZ.
- Install Tree Protection Fence before construction/demolition work (including utility digging and trenching).
- The top of the Tree Protection Fence shall be 6' above the surrounding grade.
- Tree Protection Fence shall be VTrans Standard F-2 Chain Link Fence (Type 1)
- Avoid disturbing tree roots with posts.
- Set Posts a minimum of 36" into existing grade.
- Where Tree Protection Fence is installed within the root zones of existing trees, posts shall not be set in concrete.
- Tree Protection Fence shall not be removed until the completion of all construction activity.

Root Pruning & Trenching

- Where roots are encountered at the TPZ boundary, root pruning, or the decision to expand the TPZ, shall occur under the direction of a project's licensed landscape architect, an ISA certified arborist, or the City Arborist.
- Where new utility trenches must pass through the TPZ, utilize air-trenching or horizontal boring to avoid tree root disturbance. Mechanical digging/trenching is prohibited without approval of the City Arborist.
- No roots larger than two inches (2") shall be cut unless no other alternative is feasible and upon the approval of the City Arborist.

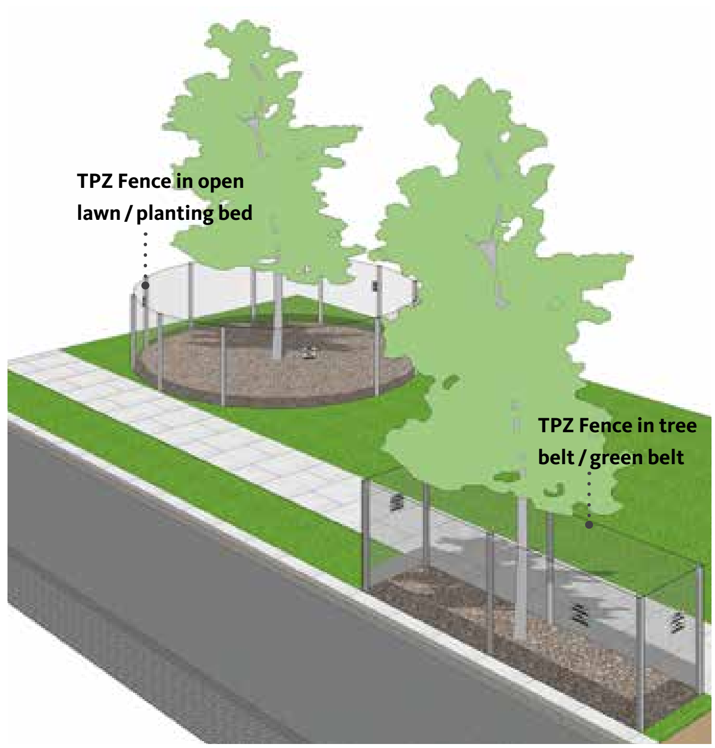
Mulch

- Apply a mulch at a loose depth of 3" to cover the entire TPZ.
- Mulch shall be made of wood chips, or triple-shredded pine or hardwood bark. It must be free from deleterious materials, suitable as a top-dressing in planted areas, and brown in color.
- Bare soil should be left at the base of the tree to avoid trunk suffocation or rot.

Tree Protection Sign

- Install Tree Protection Signs at 25' intervals along all Tree Protection Fences. (min. 1 sign per TPZ)
- Signs shall be white, 10" × 12" and made of a durable & weatherproof material.
- Sign text shall be black with a minimum letter height of ½".
- Required sign text:

NO ENTRY—TREE PROTECTION ZONE.
DO NOT PLACE MATERIALS
OR EQUIPMENT IN THIS AREA



Soil & Subsurface

Proper soil selection and management is one of the best ways to support healthy vegetation and to improve stormwater management in urban areas. Healthy soils—soils that have a high organic content and plenty of pore space—support healthier trees and plants and promote more groundwater recharge and better filtration of stormwater. Heavily compacted soils act almost like pavement, absorbing little water and supporting less biological activity than well aerated soils.

Soils within tree belts and planted areas that have become compacted and degraded can be significantly improved with aeration and/or the addition of soil amendments, such as weed-free compost, to help retain soil moisture. Soil improvements can make a significant difference in the health and longevity of trees and other vegetation can also improve stormwater management. Soil maintenance should be part of an operation and maintenance plan for urban vegetation.

New street trees and plantings present an opportunity to use engineered soils to grow a much larger and healthier greenscape and to clean and recharge significant volumes of stormwater runoff. Design details for planting street trees and implementing vegetated stormwater management techniques are found throughout the Street Ecology chapter. In all of these applications, careful selection of soil type and providing maximum soil volume should be priorities.

In constrained situations where existing street trees cause sidewalk heaving or where space is limited, consider using structural soils. Structural soils are a type of engineered soil that is designed to meet the load bearing requirements of urban streets while still maintaining adequate porosity and organic content to support healthy vegetation. Some structural soils also contain materials that specifically retain moisture. In urban contexts, structural soils allow the placement of ample, healthy soil beds beneath sidewalks and parking areas. Soil cells or root trenches shall be used underneath pavement to provide required soil volumes for new trees. Root trenches may pass beneath sidewalks and through retaining walls or other obstacles and must provide unobstructed root access to soils appropriate for supporting healthy tree growth. Trees and plantings can be grown in dense urban settings with paved surfaces above the root systems, provided there is a way for water to enter the structural soil mixture.

Structural soils require irrigation (passive or active) to support a variety of plant types. Overflow drains may be necessary depending on the characteristics of the surrounding soils. Structural soil applications can both provide a healthier environment for plants and better capture, filter, and recharge of stormwater.

SOIL VOLUME

- Canopy—1000 cu. ft./tree* (1500 cu. ft./tree preferred)
- Medium—1000 cu. ft./tree
- Small—600 cu. ft./tree

Adequate subsoil is essential for healthy tree growth, especially on urban streets. The ability of a tree to grow beyond a certain size is directly related to the volume of soil available for roots. Providing sufficient rooting soil in a dense, urban environment can be costly, but is worthwhile given the unique benefits that mature shade trees provide.

Tree roots do not thrive in highly compacted soil because it lacks the void spaces needed to provide air and water. Roots in compacted soil will migrate toward the surface seeking air and water, potentially cracking and heaving nearby sidewalks.

When the rooting space is inadequate, the tree roots will grow to capacity, and then the tree will decline and die.

Trees in the Northeast U.S. need approximately 2 cubic feet of soil per square foot of canopy area. For example, a tree growing in a 3' by 8' by 4' pit would be expected to reach about an 8' diameter canopy before becoming stressed and showing signs of decline. If the tree has access to soil outside the pit, the canopy can grow much larger.

* To grow a Canopy Tree to mature size in an urban environment, an uncompacted soil volume greater than 1,000 cu. ft. is needed. According to research by Dr. E. Thomas Smiley and James Urban, FASLA, the largest potential canopy that can be expected to grow with 1,000 cu. ft. of soil is 800 sq. ft. in spread (roughly 28' × 28'). In locations where larger mature trees are desired, 1,500 cu. ft./tree of uncompacted soils are recommended.

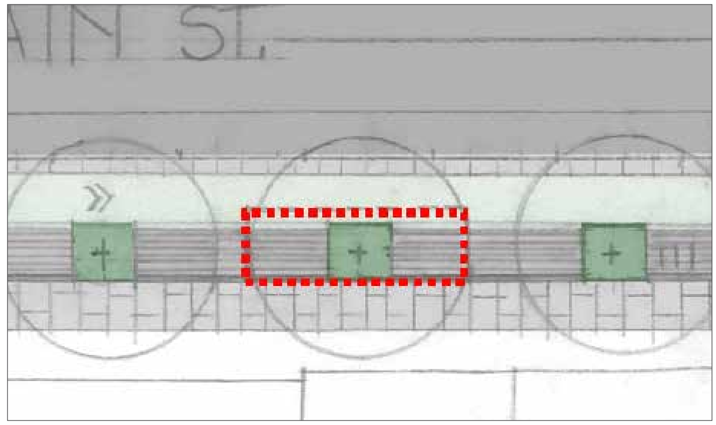
HORTICULTURAL SOIL

Intent: To provide trees, turf, and groundcover plantings with a soil that allows them to thrive and to live out their longest possible healthy life in urban conditions.

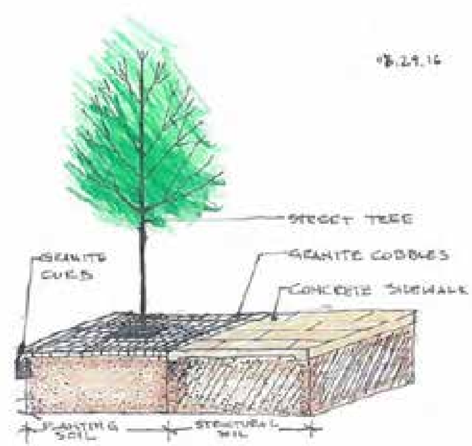
Location: Horticultural soils will fill the entire area of the tree well at a 3' minimum depth. These soils will also be used in soil cells and will provide the top 18" of the soil profile in turf Treebelts. Horticultural Soil is not intended for use in Bio-retention Plantings.

Design: Consult a soils scientist or a licensed landscape architect, horticulturist, or arborist when designing Horticultural Soils to meet site and plant specific needs.

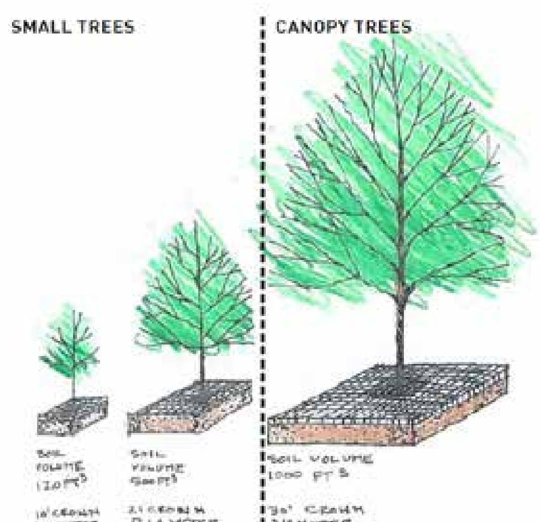
Materials: Horticultural Soil is a fertile, friable, loamy topsoil mix suitable for the support of vegetative growth.



BURLINGTON TREE CANOPY - SOIL VOLUME



One detail that could provide sufficient soil volume and permeability for trees to thrive, a permeable granite cobble band in the tree-belt. This would have the added benefit of being erosion resistant and resilient against snow removal impacts.



Soil volume has a direct impact on a tree's potential to develop into a mature size. Though each species has a specific requirement, a good rule of thumb is that 1000 cubic feet of soil volume should be allocated per tree.

Horticultural Soil Components: Topsoil, Organics, Coarse Sand, Fertilizer, and Biological Amendments

- Topsoil: Unscreened Imported Topsoil or Existing Site Soil
  - Soil Texture: USDA loam, sandy clay loam, or sandy loam.
  - Soil Structure: Retain Peds of min 2" in size prior to mixing.
  - Organic Matter & Soil Chemistry: Suitable for growing the plants specified at the designed location
  - Soil Objects: <5% of total topsoil volume: Clumps of Clay; Debris; Refuse; Roots; Stones; Sticks; Brush; or other litter. Remove all soil objects >8" in their longest dimension.
  - Contaminants. The soil should have no herbicides, heavy metals, biological toxins, or hydrocarbons that will impact plant growth or are at levels exceeding the EPA's standards for soil contaminants.
  - Source: Unscreened Imported Topsoil must be harvested within 50 miles of Burlington, Vermont. Unscreened Imported Topsoil may not contain soils from sources defined by the United States Natural Resources Conservation Service as prime farmland, unique farmland, or farmland of statewide or local importance.
- Organics: Compost shall be commercially prepared Pine Fines or an equivalent compost and must meet US Compost Council STA/TMECC criteria for "Compost as a Landscape Backfill Mix Component" and must not be derived from human waste or animal waste sources.
- Coarse Sand: Clean, washed, natural sand, free of toxic materials, limestone, salt, shale, and slate particles. Must meet ASTM-C33 Standards.
- Fertilizer: If noted by soil test recommendations, add slow-release, organic fertilizer based on soil test and plant requirements.
- Biological Amendments: Amendments such as Mycorrhizal additives, compost tea or other products intended to change the soil biology, as required based on Soil Foodweb Analysis by a qualified soil testing lab.

Horticultural Soil Mix Requirements: Blend Topsoil, Organics, Coarse Sand, Fertilizer & Biological Amendments to make a new soil that meets the Project goals for the indicated planting area.

- Clay content: 15–25% by weight
- Organic matter: 5–10% by weight
- Coarse Sand: 30–65% by weight
- Silt: 15–25% by weight
- Gravel content shall not exceed 10% by weight
- Soluble Salt: < 2 dS/m
- Cation Exchange Capacity: 7–15
- Water Permeability: 1–2 inches per hour when compacted to 85% of maximum dry density
- pH: 6.0–6.5
- At the time of soil installation, add fertilizer or biological amendments, if required, to the planting soil mix at rates recommended by soil testing results for the plants to be grown.

Depth: 3–4' (18" in turf-only areas of tree-belts where tree rooting volume is not required).

SOIL CELLS

Intent: Soil Cells provide most the required soil volume for each tree downtown. These systems protect tree rooting soil from compaction while allowing pavement, vehicular access, and other streetscape uses above.

Location: The primary location for these systems will be beneath permeable pavement in the Treebelt. These systems may also extend beneath the Concrete Sidewalk, Paved Bike Lanes, and in the Step-off zone. In residential areas, the tree-belt is planted in turf. See Figure 5 on page 188.

Systems: Three systems are approved:
- Silva Cells: manufactured by DeepRoot
- StrataVault: manufactured by GreenBlue Urban
- StrataCell: manufactured by GreenBlue Urban

Loading: Soil Cells must be designed to accommodate H-20 loading for all pavements that they support.

Soil Type: Install Horticultural Soils in Soil Cells. Horticultural Soil Mix Requirements may be modified to meet manufacturer's specifications.

Installation: Per Manufacturer specification to accommodate paving and streetscape furnishings above as well as tree grate or curb/fence.

Note: In situations where fewer than 10 soil cells are required to meet minimum soil volume requirements, designers/owners may coordinate with Burlington DPW and Parks Department to determine the best means of achieving adequate soil volume for the site.

CU-STRUCTURAL SOIL™

Intent: CU Structural Soil is a less-costly, but less-efficient method of providing rooting space for street trees beneath pavements as compared to Soil Cell systems.

Materials: CU Structural Soil is a patented mixture of crushed stone, clay loam and Hydrogel developed by Cornell University. (Patent #5,849,069)

Installation: Install per "CU-Structural Soil® A Comprehensive Guide" as published by Cornell University: *http://www.hort.cornell.edu/uhi/outreach/pdfs/CU-Structural%20Soil%20-%20A%20Comprehensive%20Guide.pdf*

Efficiency: The Smiley-Bartlett Field Study suggests that a cubic foot of CU Structural Soil is capable of supporting 20% as much mature tree canopy volume as uncompacted Horticultural Soil.

Use: In areas where soil cells cannot be used because of utilities or other underground impediments, CU Structural Soil may be used to provide no more than 20% of the required soil volume for each tree. CU Structural Soil may also be used to provide root paths beneath paved areas. Root paths provide access to nearby soils suitable for supporting tree growth that would otherwise be made inaccessible by compacted subsoils beneath paved areas.

Source: CU-Structural Soil has been patented and licensed to qualified producers to ensure quality control; its trademarked names are CU-Structural Soil® or CU-Soil®. Obtain CU-Structural Soils an Amereq-licensed company. This assures that the material has been produced and tested to meet research-based specifications.

DRAINAGE & ROOT AERATION

Intent: To prevent subgrade moisture oversaturation and provide subsurface aeration in areas of tree planting.

Material: Linear perforated subsoil drains which connect to the city's storm/combined sewer system.

Operability: Valves that can cut off drainage to the city sewer systems must be installed at each connection to the sewer system. Valves will be installed in the "off" position. Alternatively, drains may be installed without valves, at a higher elevation in the soil profile as agreed upon with the Burlington Water Resources Department. This overflow system will drain automatically when saturation reaches a designed level.

PVC Check-Wells must be installed to monitor subgrade moisture at each street tree.

Location: Underdrainage must be installed beneath all new street trees, regardless of the pre-construction infiltration rate of site soils. Drains must be installed in tree-belts beneath permeable pavements, tree wells, turf Treebelts, Soil Cells, and Sand Based Structural Soils.

Performance: Underdrains must allow saturated soils to drain by gravity to a moisture level that can support the growth of street trees.

SUBGRADE

On sites where water infiltration is appropriate beneath planting soils: Prior to installing planting soil, loosen grade below the installed planting sol to a depth of 18 inches below the sub grade elevation in areas that are compacted and do not easily drain.

Locate and avoid disturbing any existing utility lines or other subgrade structures.

Percolation tests shall be performed to confirm minimum percolation rates of 1–2 inches per hour.

On sites where water infiltration is inappropriate, provide impermeable liners and drainage pipes to drain all subsoil water into the sewer system while maintaining adequate moisture levels to support healthy plants.

Tree & Plant Species

PRINCIPLES

The selection of appropriate trees for the Burlington Streetscape is critical to growing a healthy mature canopy for the city and to meeting the City's goal of 50% urban canopy coverage by 2025.

Trees planted close to the roadway should be of a deciduous salt resistant species. Such trees do not create heavy winter shading that allows the roadway to freeze sooner and thaw later. Even large deciduous trees can have some effect on freeze and thaw cycle.

The approved tree list includes species selected for their cold-hardiness, salt tolerance, and their ability to thrive in an urban environment. The list is divided into three categories as defined by Burlington city code. They should be distributed within the downtown as follows:

Canopy Trees (mature height >50')
- All Commercial Streets

Medium Trees (mature height 25'–50')
- Commercial Slow Streets; Minimum & Major Commercial Streets; Residential Streets
- **Not** on Special Commercial Streets

Small Trees (mature height <25')
- Residential Streets
- On Commercial Streets—Beneath Power Lines or where extreme subsurface conditions prevent adequate soil volumes to support Canopy or Medium trees.

INITIAL SIZE & QUALITY

Street trees should be installed at 2.5"–3.5" caliper unless otherwise requested by the city. To maintain visibility and accommodate pedestrian flow, new trees may be limbed-up ⅓ of their total height, but not more than 8 feet above the adjacent sidewalk. All trees must be of good quality and in compliance with the most recent edition of ANSI Z60.1—American Standard for Nursery Stock published by AmericanHort. Street tree planting must be in compliance with Burlington Municipal Code. All trees must have a single trunk. No multi-stem trees may be planted in the Downtown Burlington Right of Way.

PLANTING CONDITION

TREE TYPE	Planted Tree Well	Tree Well w/ Tree Grate	Broad/Standard Green Belt	Narrow Green Belt	Bioretention (see tree list for appropriate species)
Canopy Tree	●	●	●		●
Medium Tree	●	●	●		●
Small Tree	●	●	● (only beneath power lines)	●	●

TREE SPECIES UNDER CONSIDERATION

The following list of recommended street trees was developed using the Vermont Tree Selection Guide. Additional reference materials include: The Cornell Recommended Urban Trees Guide, Michael Dirr's Manual of Woody Landscape Plants, The Missouri Botanical Garden Plant Finder, and street tree guidelines for Chicago, IL; Toronto, ON; Markham, ON; and Portland, ME.

Note: an asterisk (*) next to a species indicates that it is appropriate for bioretention/rain garden use.

Trees

Canopy Trees (mature height >50')

- *Acer × fremanii* 'Armstrong'—Armstrong Freeman Maple
- *Acer × fremanii* 'Celzam'—Celebration Freeman Maple
- *Acer × fremanii* 'Marmo'—Marmo Freeman Maple
- *Acer × fremanii* 'Sienna'—Sienna Freeman Maple
- *Acer rubrum sp.*—Red Maple *
- *Cercidiphyllum japonicum sp.*—Katsuratree
- *Celtis occidentalis sp.* —Hackberry
- *Celtis occidentalis* 'Chicagoland'—Chicagoland Hackberry
- *Celtis occidentalis* 'Prairie Pride'—Prairie Pride Hackberry
- *Ginkgo biloba* 'Autumn Gold'—Ginkgo
- *Ginkgo biloba* 'Magyar'—Ginkgo
- *Ginkgo biloba* 'Princeton Sentry'—Ginkgo
- *Gymnocladus dioicus sp.*—Kentucky Coffeetree
- *Platanus × acerifolia* 'Morton Circle'—Exclamation! London Planetree *
- *Quercus bicolor sp.*—Swamp White Oak *
- *Quercus imbricaria sp.*—Shingle Oak
- *Quercus rubra sp.*—Red Oak
- *Taxodium distichium sp.*—Baldcypress *
- *Tilia Tomentosa sp.*—Linden
- *Ulmus americana* 'Princeton'—Princeton American Elm *
- *Ulmus minor* 'Triumph'—Triumph Elm *
- *Ulmus ×* 'Morton'—Accolade Elm *
- *Ulmus ×* 'Morton Glossy'—Triumph Elm *
- *Ulmus wilsoniana* 'Patriot'—Patriot Elm *

Medium Trees (mature height 25'–50')

- *Acer miyabei* 'Morton'—State Street Miyabe Maple
- *Betula nigra* 'Cully'—Heritage River Birch
- *Betula nigra* 'Northern Tribute'—Northern Tribute River Birch *
- *Gleditsia triacanthos v. inermis* 'Halka'—Halka Honeylocust *
- *Gleditsia triacanthos v. inermis* 'Imperial'—Imperial Honeylocust
- *Gleditsia triacanthos v. inermis* 'Skyline'—Skyline Honeylocust
- *Gleditsia triacanthos v. inermis* 'Streetkeeper'—Streetkeeper Honeylocust
- *Nyssa sylvatica sp.*—Black Gum
- *Parrotia persica sp.*—Persian Ironwood

Small Trees (mature height <25')

- *Acer truncatum sp.*—Shantung Maple
- *Amelanchier arborea sp.*—Downy Serviceberry
- *Amelanchier laevis* —Allegheny Servicebery
- *Amelanchier × grandiflora*—Apple Serviceberry
- *Cercis canadensis sp.*—Eastern Redbud
- *Cornus kousa sp.*—Kousa Dogwood
- *Crataegus crus—galli* var. *inermis*—Thornless Cockspur Hawthorn
- *Crataegus viridis* 'Winter King'—Winter King Hawthorn *
- *Maackia amurensis* 'Starburst'—Starburst Amur Maackia
- *Prunus mackii* 'MN Strain'—Amur Chokecherry
- *Syringa reticulata* 'Ivory Silk'—Japanese Tree Lilac
- *Syringa reticulata* 'Summer Snow'—Japanese Tree Lilac

CANOPY TREES

***Acer x fremanii* 'Armstrong'**
Armstrong Freeman Maple

Height: 40–60'

Spread: 10–15'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No (Hybrid)

Notes: Armstrong Freeman Maple is a fast-growing, fastigiate hybrid of red and silver maples.

***Acer x fremanii* 'Celzam'**
Celebration Freeman Maple

Height: 40–45'

Spread: 20–25'

Required Soil Volume: 1000 ft^3

Planting Condition: Broad Treebelt, Turf Treebelt, Lawn Bioretention

Salt Tolerance: Moderate

VT Native: No (Hybrid)

Notes: Freeman Maple is a hybrid of red and silver maples. The cultivar 'Celzam' is recommended for its upright habit and superior resistance to wind and ice damage. This tree has shallow roots with a tendency to heave light pavements. Locate away from sidewalks.

***Acer x fremanii* 'Marmo'**
Marmo Freeman Maple

Height: 40–75'

Spread: 35–45'

Required Soil Volume: 1000 ft^3

Planting Condition: Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No (Hybrid)

Notes: Freeman Maple is a hybrid of red and silver maples. The cultivar 'Marmo' is recommended for its upright habit and superior fall color. This tree has shallow roots with a tendency to heave light pavements. Locate away from sidewalks.

CANOPY TREES

***Acer x fremanii* 'Sienna'**
Sienna Glen Freeman Maple

Height: 40–50'

Spread: 30–45'

Required Soil Volume: 1000 ft^3

Planting Condition: Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Moderate

VT Native: No (Hybrid)

Notes: Sienna Freeman Maple is a pyramidal hybrid of red and silver maples. This tree has shallow roots with a tendency to heave light pavements. Locate away from sidewalks.

***Betula nigra* 'Cully'**
Heritage River Birch

Height: 40–70'

Spread: 30–40'

Required Soil Volume: 1000 ft^3

Planting Condition: Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Moderate

VT Native: No (Hybrid)

Notes: Acer rubrum has a low salt tolerance. Locate in areas subject to the lowest possible levels of winter salt applications on nearby pavements. This tree has shallow roots with a tendency to heave light pavements. Locate away from sidewalks. Many Acer rubrum cultivars exist. Not all are tolerant of Burlington's climate. Select a cultivar or straight-species tree, grown in USDA zone 3 or 4, that is known to tolerate Burlington's winter temperatures.

***Betula nigra* 'Northern Tribute'**
Northern Tribute River Birch

Height: 50–60'

Spread: 35–40'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No

Notes: Katsura is a difficult to transplant and drought-intolerant tree that requires irrigation, especially during establishment. Do not plant in an un-irrigated treebelt condition.

CANOPY TREES

Celtis occidentalis
Common Hackberry

Height: 40–60'

Spread: 40–60'

Required Soil Volume: 1000 ft^3

Planting Condition: Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Good

VT Native: Yes

Notes: Hackberry is resilient against salt and cold, but can be slow to heal wounds. Avoid using this tree in areas where automobile impacts or other significant injuries are anticipated.

Celtis occidentalis **'Chicagoland'**
Chicagoland Hackberry

Height: 40–60'

Spread: 20–30'

Required Soil Volume: 1000 ft^3

Planting Condition: Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Good

VT Native: Yes

Notes: The Chicagoland cultivar was selected for its upright, single-trunked habit.

Celtis occidentalis **'Prairie Pride'**
Common Hackberry

Height: 40–55'

Spread: 40–50'

Required Soil Volume: 1000 ft^3

Planting Condition: Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Good

VT Native: Yes

Notes: Prairie Pride is more resistant to Witches Broom than the species.

CANOPY TREES

***Ginkgo biloba* 'Autumn Gold'**
Autumn Gold Ginkgo

Height: 40–50'

Spread: 20–30'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Moderate

VT Native: No

Notes: Autumn Gold is a fruitless, male cultivar.

***Ginkgo biloba* 'Magyar'**
Magyar Ginkgo

Height: 40–50'

Spread: 20–25'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Good

VT Native: No

Notes: Magyar is a fruitless, male cultivar.

***Ginkgo biloba* 'Princeton Sentry'**
Princeton Sentry Ginkgo

Height: 40–60'

Spread: 20–25'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No

Notes: Princeton Sentry is a fruitless, male cultivar.

CANOPY TREES

Gymnocladus dioicus
Kentucky Coffeetree

Height: 50–70'

Spread: 40–50'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Moderate

VT Native: No (Eastern US Native)

Notes: In locations where seed pods are undesirable, select a male cultivar such as 'Espresso.'

***Platanus x acerifolia* 'Morton Circle' Exclamation! London Planetree**

Height: 55–65'

Spread: 40–50'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Moderate

VT Native: No (Hybrid)

Notes: Southern grown trees of this species may be cold-sensitive. Plant trees grown in USDA zone 4.

This species is appropriate for bioretention/ raingarden use.

Quercus bicolor
Swamp White Oak

Height: 50–60'

Spread: 50–60'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Moderate

VT Native: Yes

Notes: Swamp White Oak will not tolerate alkaline soils. Plant in a location with soil ph < 7.5. Consider the appropriateness of acorns in the streetscape context when selecting an appropriate site for this tree.

This species is appropriate for bioretention/ raingarden use.

CANOPY TREES

Quercus imbricaria
Shingle Oak

Height: 40–60’

Spread: 40–60’

Required Soil Volume: 1000 ft^3

Planting Condition: Broad Treebelt, Lawn

Salt Tolerance: Good

VT Native: No (Eastern US Native)

Notes: Shingle Oak will not tolerate saturated soils. Plant in a well-drained location. Consider the appropriateness of acorns in the streetscape context when selecting an appropriate site for this tree.

Quercus rubra
Northern Red Oak

Height: 50–75’

Spread: 50–60’

Required Soil Volume: 1000 ft^3

Planting Condition: Broad Treebelt, Lawn

Salt Tolerance: Good

VT Native: Yes

Notes: Red Oak will not tolerate saturated soils. Plant in a well-drained location. Consider the appropriateness of acorns in the streetscape context when selecting an appropriate site for this tree.

Taxodium distichium
Baldcypress

Height: 50–70’

Spread: 20–30’

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Moderate

VT Native: No (Northeast Native)

Notes: Southern grown trees of this species may be cold-sensitive. Plant trees grown in USDA zone 4.

This species is appropriate for bioretention/ raingarden use.

CANOPY TREES

Tilia tomentosa
Silver Linden

Height: 50–70'

Spread: 30–55'

Required Soil Volume: 1000 ft^3

Planting Condition: Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No

Notes: Southern grown trees of this species may be cold-sensitive. Plant trees grown in USDA zone 3 or 4.

***Ulmus americana* 'Princeton'**
Princeton American Elm

Height: 50–60'

Spread: 30–50'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Moderate

VT Native: Yes

Notes: Southern grown trees of this species may be cold-sensitive. Plant trees grown in USDA zone 3 or 4.

This species is appropriate for bioretention/ raingarden use.

***Ulmus x* 'Morton'**
Accolade Elm

Height: 50–60'

Spread: 30–40'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Moderate

VT Native: No (Hybrid)

Notes: Southern grown trees of this species may be cold-sensitive. Plant trees grown in USDA zone 3 or 4.

This species is appropriate for bioretention/ raingarden use.

CANOPY TREES

***Ulmus x spp.* 'Morton Glossy'**
Triumph Elm

Height: 50–60'

Spread: 35–40'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Moderate

VT Native: No (Hybrid)

Notes: Southern grown trees of this species may be cold-sensitive. Plant trees grown in USDA zone 3 or 4.

This species is appropriate for bioretention/ raingarden use.

***Ulmus x spp.* 'Patriot'**
Patriot Elm

Height: 40–50'

Spread: 20–25'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Moderate

VT Native: No (Hybrid)

Notes: Southern grown trees of this species may be cold-sensitive. Plant trees grown in USDA zone 3 or 4.

This species is appropriate for bioretention/ raingarden use.

MEDIUM TREES

***Acer miyabei* 'Morton'**
State Street Miyabe Maple

Height: 30–40'

Spread: 30–40'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No

Notes: The cultivar 'Morton' is recommended for its superior cold-hardiness, symmetrical habit, and fall color.

***Betula nigra* 'Cully'**
Heritage River Birch

Height: 40–50'

Spread: 30–35'

Required Soil Volume: 1000 ft^3

Planting Condition: Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Moderate

VT Native: Yes

Notes: The cultivar 'Cully' is recommended for its superior cold tolerance and bark color. Single-stem trees are recommended for street tree planting. Lower branch pruning will be necessary for trees planted close to sidewalks. Do not plant in areas of high pedestrian traffic.

This species is appropriate for bioretention/ raingarden use.

***Betula nigra* 'Northern Tribute'**
Northern Tribute River Birch

Height: 35–40'

Spread: 30–35'

Required Soil Volume: 1000 ft^3

Planting Condition: Broad Treebelt, Turf Treebelt, Lawn, Bioretention

Salt Tolerance: Moderate

VT Native: Yes

Notes: An extremely cold tolerant Riverbirch. Single-stem trees are recommended for street tree planting. Lower branch pruning will be necessary for trees planted close to sidewalks. Do not plant in areas of high pedestrian traffic.

This species is appropriate for bioretention/ raingarden use.

MEDIUM TREES

Gleditsia triacanthos v. inermis
Halka Honeylocust

Height: 30–40'

Spread: 30–40'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Narrow Treebelt, Lawn

Salt Tolerance: Good

VT Native: Yes

Notes: Halka is a nearly fruitless, thornless Honeylocust cultivar.

Gleditsia triacanthos v. inermis
Imperial Honeylocust

Height: 25–30'

Spread: 30–35'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Narrow Treebelt, Lawn

Salt Tolerance: Good

VT Native: Yes

Notes: Imperial is a nearly fruitless, thornless Honeylocust cultivar. It is one of the most compact Honeylocusts.

Gleditsia triacanthos v. inermis
Skyline Honeylocust

Height: 35–45'

Spread: 30–35'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Narrow Treebelt, Lawn

Salt Tolerance: Good

VT Native: Yes

Notes: Skyline has a somewhat pyramidal form. It is a thornless and nearly fruitless Honeylocust cultivar.

MEDIUM TREES

Gleditsia triacanthos v. inermis
Streetkeeper® Honeylocust

Height: 45'

Spread: 20'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Narrow Treebelt, Lawn

Salt Tolerance: Good

VT Native: Yes

Notes: Streetkeeper is a a thornless and nearly fruitless Honeylocust cultivar with a unique, upright habit.

Betula nigra **'Cully'**
Heritage River Birch

Height: 30–50'

Spread: 20–30'

Required Soil Volume: 1000 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Narrow Treebelt, Lawn, Bioretention

Salt Tolerance: Moderate

VT Native: Yes

Notes: Black Tupelo is a slow growing and somewhat low-branched tree. It has fantastic red fall color and is good for poorly-drained soils.

Betula nigra **'Northern Tribute'**
Northern Tribute River Birch

Height: 20–40'

Spread: 20–30'

Required Soil Volume: 1000 ft^3

Planting Condition: Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Low

VT Native: No

Notes: Southern grown trees of this species may be cold-sensitive. Plant trees grown in USDA zone 3 or 4. Parrotia has a low salt tolerance. Locate in areas subject to the lowest possible levels of winter salt applications on nearby pavements.

SMALL TREES

***Acer truncatum* 'Main Street'**
Shantung Maple

Height: 20–25'

Spread: 20–30'

Required Soil Volume: 600 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Narrow Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No

Notes: Good under power lines. Compact, somewhat low-branched street tree.

Amelanchier arborea
Downy Serviceberry

Height: 15–25'

Spread: 15–25'

Required Soil Volume: 600 ft^3

Planting Condition: Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: Yes

Notes: 'Spring Flurry' cultivar is recommended for its fastigiate form. Good under power lines in residential areas. Avoid areas of high soil compaction.

Amelanchier laevis sp.
Allegheny Servicebery

Height: 15–25'

Spread: 15–25'

Required Soil Volume: 600 ft^3

Planting Condition: Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: Yes

Notes: 'Snowcloud' and 'Majestic' cultivars are recommended for their form and vigor. Good under power lines in residential areas. Avoid areas of high soil compaction.

SMALL TREES

Amelanchier x grandiflora
Apple Serviceberry

Height: 15–25’

Spread: 15–25’

Required Soil Volume: 600 ft^3

Planting Condition: Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No (Hybrid)

Notes: ‘Autumn Brilliance’ and ‘Autumn Sunset’ cultivars are recommended for their form and color. Good under power lines in residential areas. Avoid areas of high soil compaction.

***Cercis canadensis* 'MN Strain'**
Eastern Redbud

Height: 15–25

Spread: 15–25’

Required Soil Volume: 600 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Narrow Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No (Eastern US Native)

Notes: Low-branched tree. Locate to avoid pedestrian conflicts. Must be "MN Strain" to be hardy here. Must be planted in a location protected from winter winds.

Cornus kousa sp.
Kousa Dogwood

Height: 15–20’

Spread: 15–20’

Required Soil Volume: 600 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No

Notes: A broad and low-branched tree. Locate to avoid pedestrian conflicts. Southern grown trees of this species may be cold-sensitive. Plant trees grown in USDA zone 4. Select cold-hardy cultivars.

SMALL TREES

Crataegus crus-galli var. inermis
CRUSADER Thornless Hawthorn

Height: 20–25

Spread: 20–25'

Required Soil Volume: 600 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: Yes

Notes: Tough tree suitable for urban conditions, Requires good soil drainage. Thornless.

***Crataegus viridis* 'Winter King'**
Winter King Hawthorn

Height: 20–25'

Spread: 20–25'

Required Soil Volume: 600 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No (Eastern US Native)

Notes: Tough tree suitable for urban conditions, Requires good soil drainage. Thorny. Lower branches will require pruning when planted near sidewalks.

This species is appropriate for bioretention/ raingarden use.

***Syringa reticulata* 'Summer Snow'**
Japanese Tree Lilac

Height: 15–20'

Spread: 15–20'

Required Soil Volume: 600 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Narrow Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No

Notes: Cultivar is smaller than the species. Attractive bark and heavy summer bloom. May reseed. Do not plant near natural areas.

SMALL TREES

***Maackia amurensis* 'Starburst'**
Starburst Amur Maackia

Height: 20–25'

Spread: 20–25'

Required Soil Volume: 600 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Narrow Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No

Notes: Slow growing. Good under power lines.

Prunus mackii sp.
Amur Chokecherry

Height: 20–30'

Spread: 18–25'

Required Soil Volume: 600 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Narrow Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No

Notes: Requires pruning to maintain tree form. White spring flowers & beautiful exfoliating bark.

***Syringa reticulata* 'Ivory Silk'**
Japanese Tree Lilac

Height: 20–25'

Spread: 15–20'

Required Soil Volume: 600 ft^3

Planting Condition: Brick Treebelt, Broad Treebelt, Turf Treebelt, Narrow Treebelt, Lawn

Salt Tolerance: Moderate

VT Native: No

Notes: Cultivar is slightly smaller than the species. Attractive bark and heavy summer bloom. May reseed. Do not plant near natural areas.

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OTHER PLANT SPECIES

Note: an asterisk (*) next to a species indicates that it is appropriate for bioretention/rain garden use.

Perennials

- *Achillea millefolium* —Common Yarrow
- *Acorus americanus*—Sweetflag *
- *Agastache foeniculum*—Anise Hyssop
- *Allium cernuum*—Nodding Onion
- *Asclepias tuberosa*—Butterfly Weed *
- *Aster novae-angliae*—New England Aster
- *Aster divaricatus*—White Wood Aster
- *Aquilegia canadensis* —Columbine
- *Baptisia australis*—Blue False Indigo
- *Callirhoe involucrata* —Winecups
- *Coreopsis tripteris* 'Gold Standard'—Tall Tickseed
- *Echinacea purpurea* —Purple Coneflower
- *Eryngium yuccifolium*—Rattlesnake Master
- *Helianthus divaricatus*—Sunflower
- *Heuchera macrorhiza* 'Autumn Bride'—Autumn Bride Coral Bells
- *Heuchera longiflora*—Longflower Alumroot
- *Iris versicolor*—Blueflag *
- *Liatris spicata*—Spike Gayfeather *
- *Lobelia cardinalis*—Cardinal Flower *
- *Lupinus perennis*—Sundial Lupine
- *Monarda bradburiana*—Eastern beebalm *
- *Monarda didyma*—Beebalm *
- *Monarda fistulosa*—Wild Bergamot *
- *Oenothera fruticosa*—Sundrops
- *Penstemon digitalis*—Beardtongue *
- *Phlox subulata*—Moss Phlox
- *Rudbeckia fulgida*—Black Eyed Susan *
- *Salvia nemorosa*—Garden Sage
- *Sedum* 'Autumn Joy'—Autumn Joy Sedum
- *Solidago sempervirens* —Seaside Goldenrod *

Grasses

- *Bouteloua curtipendula* —Sideoats Grama
- *Bouteloua gracilis*—Blue Grama Grass
- *Chasmanthium latifolium*—Northern Sea Oats *
- *Juncus effusus* —Soft Rush *
- *Juncus tenuis* —Poverty Rush *
- *Panicum* 'Cape Breeze' —Cape Breeze Switchgrass *
- *Schizachyrium scoparium* —Little Bluestem *

Shrubs

- *Aronia melanocarpa*—Black Chokeberry *
- *Clethra alnifolia* —Sweet Pepperbush *
- *Cornus racemosa*—Gray Dogwood *
- *Cornus sericea* —Redtwig Dogwood *
- *Hamamelis virginiana* —Witchhazel
- *Hypericum kalmianum*—Kalm's St. John's wort
- *Hypericum prolificum*—Shrubby St. John's Wort
- *Ilex glabra* —Inkberry Holly *
- *Ilex verticillata* —Winterberry Holly *
- *Myrica pensylvanica* —Bayberry *
- *Physocarpus opulifolius*—Ninebark
- *Prunus maritima*—Beach Plum *
- *Rhus aromatica* 'Gro-Low' —'Gro-Low' Fragrant Sumac *
- *Salix discolor*—Pussy Willow *
- *Viburnum dentatum*—Arrowwood *
- *Viburnum lentago*—Nannyberry Viburnum *
- *Yucca filamentosa*—Adam's Needle

Vines

- *Parthenocissus quinquefolia* —Virginia Creeper *
- *Lonicera sempervirens*—Trumpet Honeysuckle
- *Hydrangea arborescens*—Climbing Hydrangea
- *Humulus lupulus var*—Hops, Magnum or Cascade

Examples of Proposed Plant Species


Allium cernuum—Nodding Onion


Aster novae angliae—White Wood Aster


Baptisia australis—Blue False Indigo


*Monarda bradburiana—Eastern Beebalm **


Sedum 'Autumn Joy'—Autum Joy Sedum


Bouteloa gracilis—Sideoats Grama


*Chasmanthium latifolium—Northern Sea Oats **


*Juncus effusus— Soft Rush**


*Panicum 'Cape Breeze'—Cape Breeze Switchgrass **


*Clethra alnifolia—Sweet Pepperbush **


Hamamelis virginiana—Witchhazel


*Ilex glabra—Inkberry Holly **


*Ilex verticillata—Winterberry Holly **


*Myrica pennsylvanica—Bayberry **


*Rhus aromatica—Fragrant Sumac **


*Salix discolor—Pussy Willow **

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Stormwater

Toolkit

Given the economic, aesthetic, and health impacts of water pollution, compounded by climate change and more frequent and heavy rain, the City of Burlington is working to identify new ways to manage stormwater more effectively. The most efficient and cost-effective way to do this is through small scale, landscape-based stormwater practices throughout the city to collect and manage stormwater where it falls.

Increasing the amount of urban vegetation will send more water into the air as vapor through either evaporation or transpiration from plants. This will both reduce the overall volume of runoff that is generated by rainfall and cool the air. Trees are the first line of defense for these processes by allowing leaves and branches to capture rainfall before it hits the ground. Other ground plane vegetation systems, such as grass, rain gardens, swales, and planters, can significantly improve storm water management compared to hardscape when they are designed to capture stormwater runoff. Where hardscape is necessary to provide stabilized and accessible walking surfaces, strong consideration should be given to pervious pavement systems.

There are many important considerations when selecting the right type of vegetation, including resistance to vehicular emissions and salt; tolerance to drought and inundation; sight line requirements; the ability to remediate pollutants; resistance to insects and disease; and the amount of maintenance required.

The stormwater strategies described in this section are related to each other and should be customized for specific locations, both urban downtown and residential conditions. A street may have more than one stormwater strategy that is appropriate for the site and often multiple strategies are used to maximize the amount of stormwater captured, filtered, and infiltrated. Because most of the downtown study area is within Burlington's Combined Sewer Area, it is important to infiltrate and delay the flow of stormwater entering the piped system to lessen the burden on the City's main Wastewater Treatment Plant.

Landscape architects and civil engineers must survey existing soil and drainage conditions, create an overall drainage and recharge plan, and specify the various components according to the opportunities and constraints for a particular project and location. The goal is to not only manage stormwater runoff in a more sustainable and cost-effective way, but to also create beautiful and safe streets for downtown Burlington. The City should consider ways to embed public engagement, public art, or other interpretive elements into these treatments to communicate the importance of these treatments.

Maintenance requirements can include, but are not limited to:

- Removal of sediment, litter, and debris as needed. Ideally this would be done at a minimum on a quarterly basis.
- Clean out of pretreatment areas and forebays twice per year. Once after leaf fall (approx. Nov 15) and once in the spring after snow melt (approx. May 1). More frequent visits may be needed on certain streets that have considerable leaf debris throughout the year.
- Annual replacement of dead plants and mulch, as needed.
- Weeding of landscape as needed, but at least once a year.
- Aeration and/or replacement of soils if clogging or standing water are observed for more than 48 hours after a rain event.
- Inspection of inflow and overflow points, and other structural components such as check dams, should occur every three months, and after large rain events.
- Spring cleaning if area is frequently covered with snow accumulation. It is highly preferred that stormwater landscapes NOT be sites for storing snow as it will greatly diminish their functional lifespan. Close coordination with Public Works should take place to find alternative sites for dumping snow.

Species that may be considered for any facilities that include planted material within them can be found in *"Tree Species Under Consideration" on page 195* and *"Other Plant Species" on page 212.*

	Stormwater Toolkit Matrix	**Downtown Residential Streets**		**Commercial Streets**	**Other Streets**	
		Single-Family	Multi-Family	Minimum Slow Slow (w/ transit) Special Major	Alleys	Pedestrian-Only Streets
ROADWAY ZONE	**Stormwater Curb Extensions**	●	●	●		
	Green Gutters	●			●	●
	Rain Gardens	●	●	●		●
	Pervious Pavers in Parking Zone *(Pilot before expanding to other areas)*	●			●	
PEDESTRIAN ZONE	**Pervious Pavers in Treebelt Zone**		●	●		●
	Stormwater Planters w/o Street Parking	●	●	●		●
	Stormwater Planters w/ Street Parking		●			
	Tree Pit Stormwater Planters		●	●		●
	Tree Trench Stormwater Planters (Vegetated Swales)		●	●		●
	Tree Grates in Stormwater Planters			●		●

Roadway Zone

STORMWATER CURB EXTENSIONS

Stormwater curb extensions are landscape areas that extend into the street's parking zone to capture stormwater runoff. Conventional curb extensions (e.g., bulb outs, chokers, chicanes) are commonly used to increase pedestrian safety and help calm traffic. A stormwater curb extension shares these same attributes plus adds a stormwater benefit by allowing water to flow into the landscape space. In Burlington's downtown area, stormwater curb extensions should be considered at many intersections and mid-block locations, even if there are existing conventional curb extensions already in place.

The landscape space and profile of stormwater curb extensions can be designed with the physical characteristics of vegetated swales with 4:1 side slopes (see page *page 234*) or stormwater planters with vertical conditions, or a hybrid of both, depending on the available space and specific site conditions.

Stormwater curb extensions are particularly advantageous in retrofit situations because they can often be added to existing streets with minimal disturbance. The small footprint of stormwater curb extensions allows for an efficient stormwater management system that often performs very well for a relatively low implementation cost.

Stormwater curb extensions can be used in a variety of land uses from low-density residential streets to highly urbanized commercial streetscapes. Curb extensions are excellent to use in Burlington's steeper slope conditions because they can act as a "backstop" for capturing runoff from a curbline's upstream flow. Stormwater curb extensions can be planted with a variety of trees, shrubs, grasses and groundcovers depending on site context and conditions and in accordance with the appropriate maintenance cycle.

Urban stormwater curb extensions are often designed to be shorter in length and smaller in size than residential stormwater curb extensions to balance the need for on-street parking. Stormwater curb extensions can be placed intermittently along a street in order to support street trees within the parking zone at regular frequency. Stormwater curb extensions can be spatially confined just to the street's parking zone or they can reach into the tree belt zone for additional landscape space. If there are mature trees already present within the tree belt zone, it is common practice to only extend into the parking zone to avoid disturbing existing tree roots. Stormwater curb extensions can also be integrated with other amenities, such as interesting seating arrangements, artwork, information kiosks, etc., to create a parklet space.

An urban street with stormwater curb extensions at a street intersection that incorporate pedestrian ramps.

An urban street with stormwater curb extensions that captures the tree belt zone with new street trees and extends out into the street.

A residential street with stormwater curb extensions that only extends out into the street to preserve the existing street trees.

Key Design Considerations

Dimensional Requirements

4' minimum, 8' ideal, cross section width. Minimum length to be determined by appropriate sizing of contributing stormwater Drainage Management Area (DMA) and balanced against the desired amount of parking spaces.

Stormwater Entry

A 2' minimum width standard curb cut at the flowline of the street to allow runoff to enter the curb extension. Surface grading around the curb cut should freely direct water through the curb cut.

Sediment Forebay

3' square flat-bottom concrete forebay pad should be placed immediately downstream of the entry curb cut 4" lower than the street gutter grade to allow for sediment to drop out onto the concrete pad before entering the landscape area. Vegetation can also be placed around the concrete pad to act as a natural dam to incent sediment and trash particles to settle in the forebay area. The inlet design shall ensure flow is directed into the system in a non-erosive manner.

Water Retention Depth

Maximum water retention depth should be 6" of water and can be controlled using check dams and weirs. Stormwater curb extensions should have check dams installed for street slopes over 2%. For streets slopes over 5%, the interior of the curb extensions should be terraced with check dams and act more as a series of planters.

Grading Considerations

Grade changes directly abutting pedestrian walkways should transition at a maximum 4:1 side slope towards the facility's lowest elevation. Grade changes from the vehicular side of the curb extension should also transition at a 4:1 side slope and match the street grade elevation prior to grade transition. In some cases where terracing the grade is desirable, creating a flat-bottom grading condition with respect to the street-side curb can be achieved, but care should be taken to not have an overly deep grading condition.

Compost

Low-P compost (<0.5% P dry weight basis) is required in bioretention planting areas for the establishment phase. Allowable Phosphorous (P) content for bioretention media is 12 to 30 mg/kg per Mehlich III (or equivalent) test. (Source MnDOT 3890) Low-P compost can be created using yard, leaf, and wood waste. Manures, biosolids, and food waste are not acceptable sources for Low-P compost.

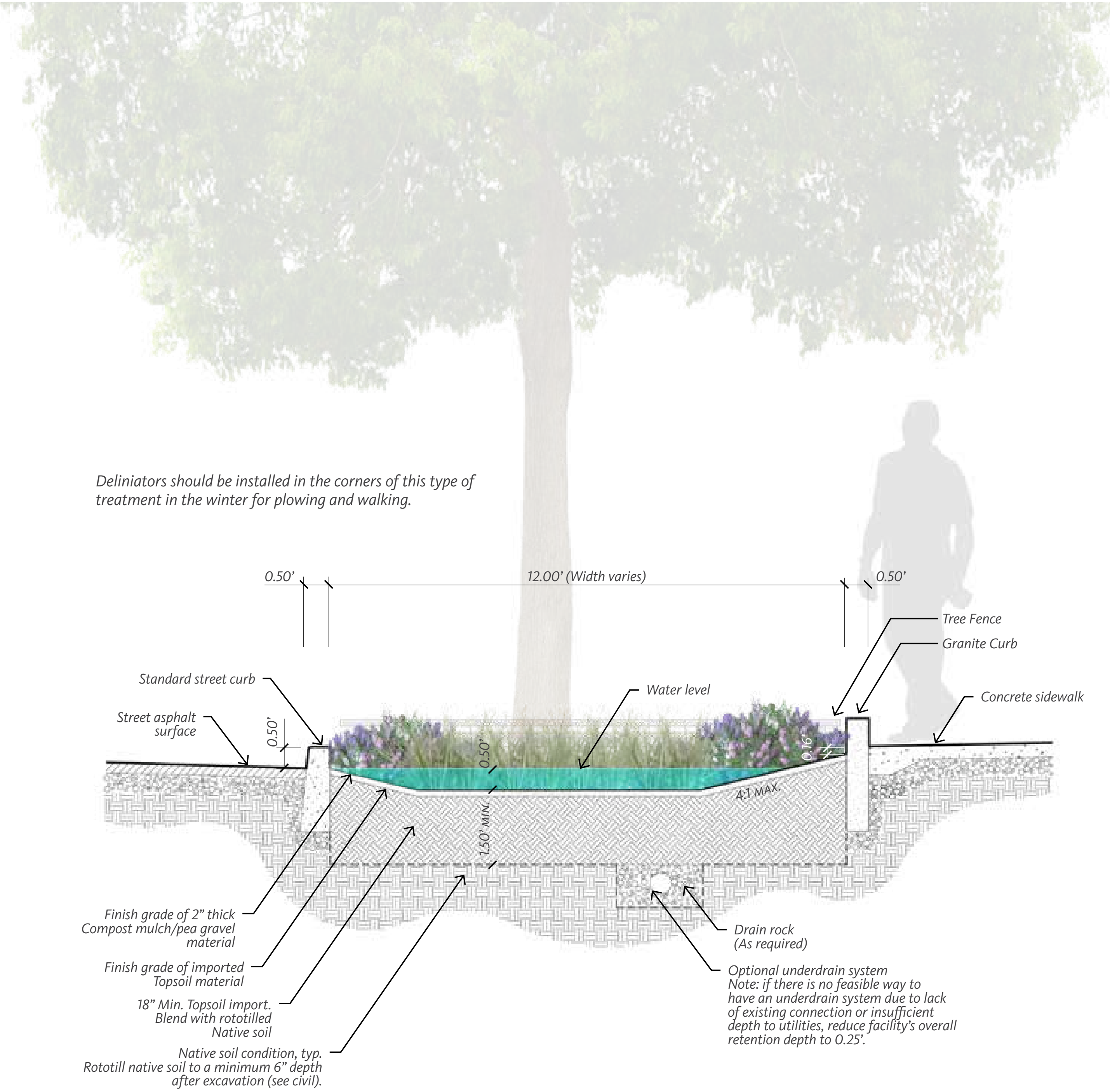
Reference Drawings

See ref. dwg. **SW–01A & B Stormwater Curb Extension (No Capture of Landscape Strip)** in *Appendix section A-6*.

See ref. dwg. **SW–02A & B Stormwater Curb Extension (Capturing Landscape Strip)** in *Appendix section A-6*.

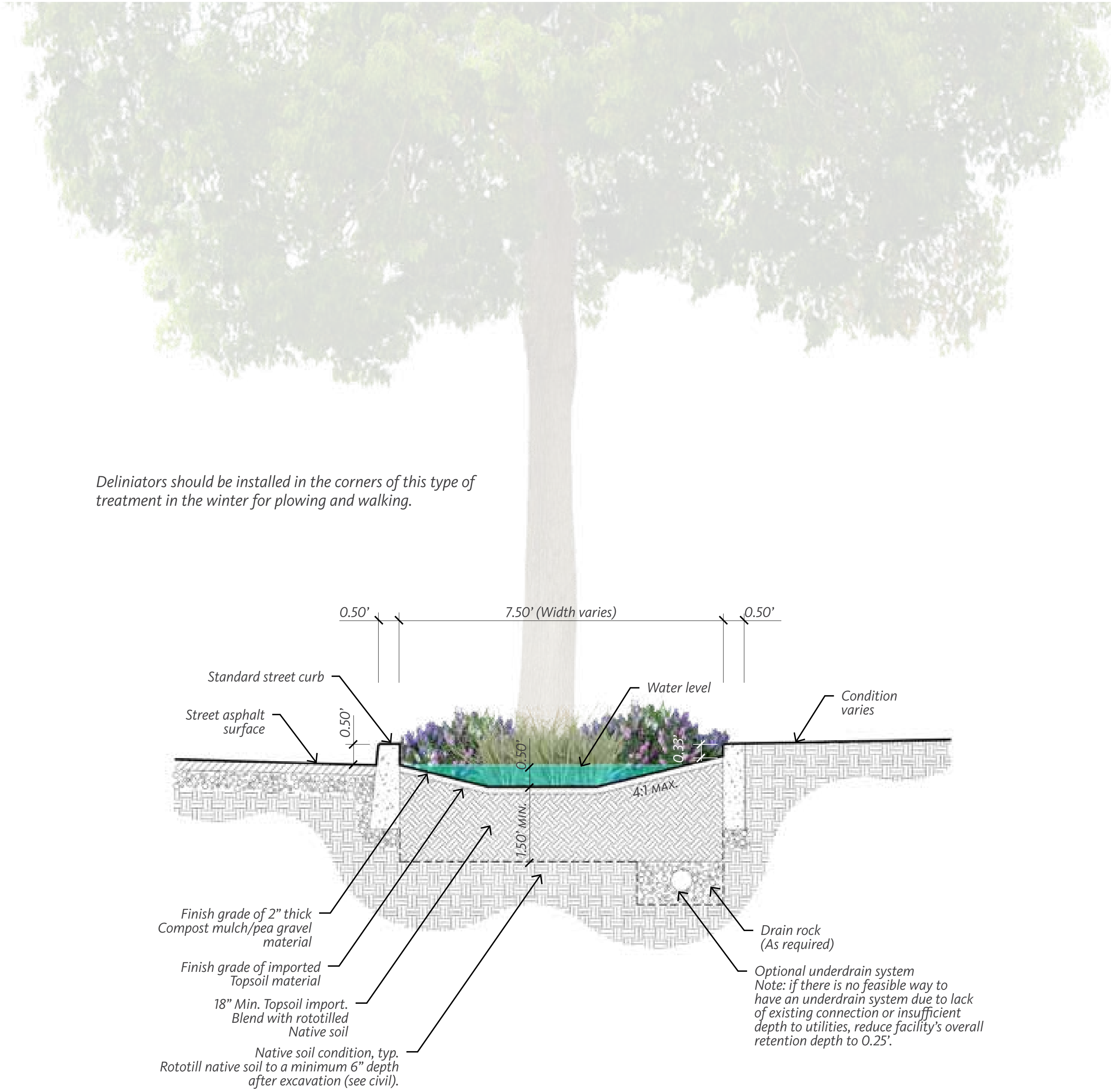
Stormwater Curb Extension Section (Capturing Landscape Strip)

This condition captures portion of sidewalk/furnishing zone runoff.



Stormwater Curb Extension Section (No Capture of Landscape Strip)

This condition does not capture portion of sidewalk/furnishing zone runoff.



GREEN GUTTERS

Green gutters are narrow landscape systems along a street's curbline that capture and slow stormwater flow. Green gutters are used on streets that do not have adjacent on-street parking and can fit along the curbline between driveway locations, if any.

Typically less than three feet wide, green gutters most resemble planters in that they are confined by vertical curbs and have a flat-bottom profile. Unlike typical planters, however, green gutters are designed to be very shallow. Green gutters can be designed as curbless systems (on streets without on-street parking, and with or without bike facilities adjacent to the curb) or with a standard raised curb (on streets with on-street parking).

The most promising use of green gutters is along excessively wide streets that do not require, or need, on-street parking. In downtown Burlington, there are several residential streets that have street parking only on one side of the street or do not allow any on-street parking. The travel lanes on some of these streets can be narrowed enough to yield room for a green gutter application, or combining this asphalt reduction with existing landscape area can also provide space for a green gutter application.

Green gutters have other benefits besides filtering stormwater pollutants and infiltrating runoff from roadways. They also introduce more green space along streets that lack landscaping. Furthermore, these narrow strips of green help provide a landscape buffer between auto traffic and pedestrians, resulting in a more desirable and potentially safer condition for people.

A curbless residential green gutter separates vehicular traffic from the sidewalk zone.

A residential green gutter on a steep street that uses check dams and weirs to terrace the street grade.

A residential bike and pedestrian path with a curbless green gutter accepting sheet flow of runoff.

Key Design Considerations

Dimensional Requirements

1.5’ minimum, 3’ maximum, cross section width. Minimum length to be determined by appropriate sizing of contributing stormwater Drainage Management Area (DMA) and the ability to fit the green gutter system between driveway locations.

Stormwater Entry

If curbs are required, place 2’ minimum width standard curb cuts at the flowline of the street at regular frequencies to allow runoff to enter the green gutter. Surface grading around the curb cuts should freely direct water through the curb cut. If the green gutter is a flush condition, make sure that there is a continuous minimum 2” drop from the flow line to the top of mulch to direct sheet flow into the landscape.

Sediment Forebay

If sheet flow is used, no sediment forebay is required. If curb cuts are used, 1.5’ square flat-bottom concrete forebay pads should be placed immediately downstream of the entry curb cuts 2” lower than the street gutter grade to allow for sediment to drop out onto the concrete pad before entering the landscape area. Vegetation can also be placed around the concrete pad to act as a natural dam to allow sediment and trash particles to settle in the forebay area. The inlet design shall ensure flow is directed into the system in a non-erosive manner.

Water Retention Depth

Maximum water retention depth should be 6” of water and can be controlled using check dams and weirs. Stormwater curb extensions should have check dams installed for street slopes over 2%. For streets slopes over 5%, the interior of the curb extensions should be terraced with check dams and act more as a series of planters.

Grading Considerations

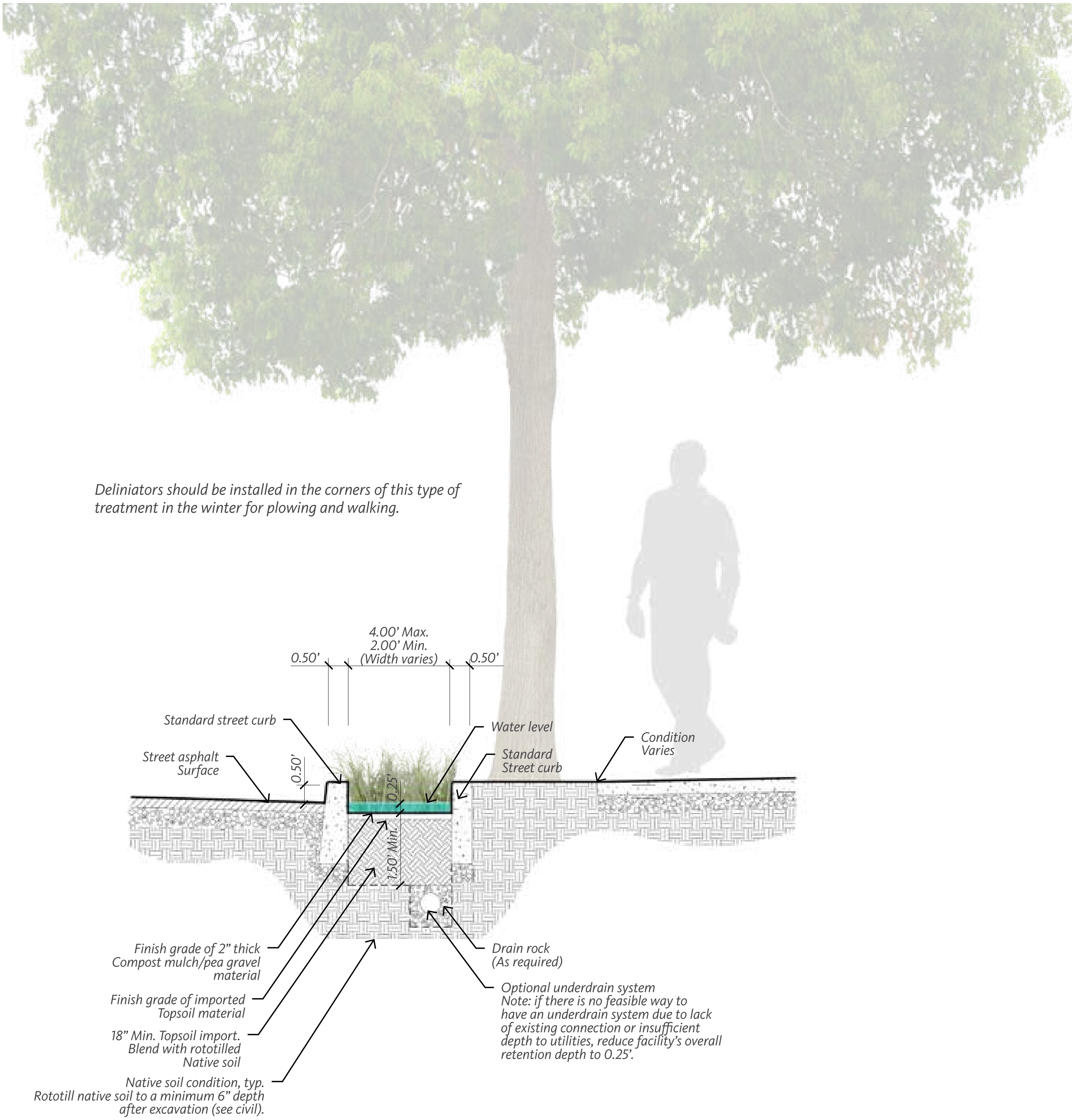
The cross section grades in green gutters should be flat with a 2” vertical drop in grade from the street grade.

Reference Drawings

See ref. dwg. **SW–03A & B Green Gutter (With Raised Street Curb)** in *Appendix section A-6*.

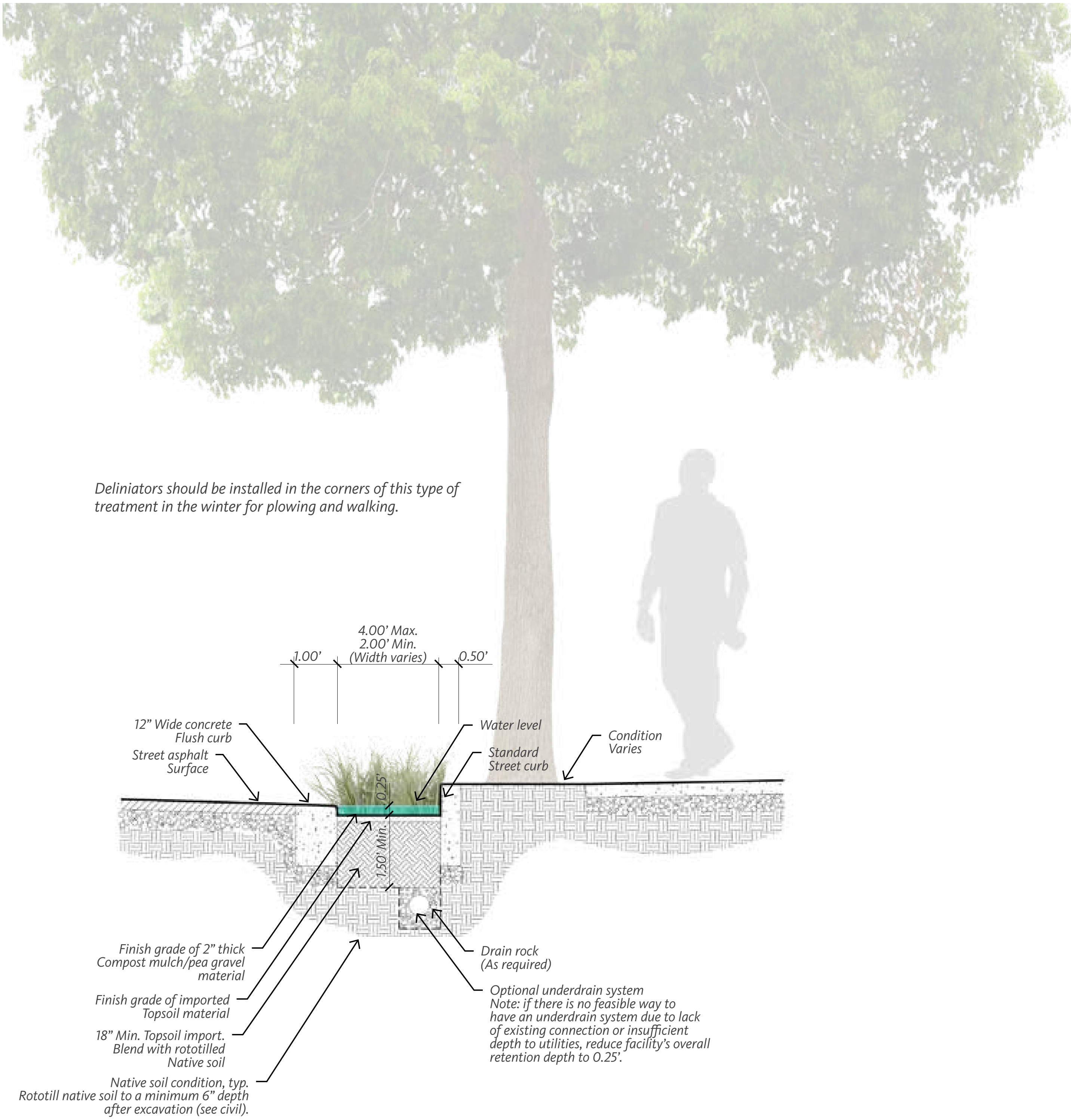
See ref. dwg. **SW–04A & B Green Gutter (With Raised Street Curb)** in *Appendix section A-6*.

Green Gutter Section (With Raised Street Curb—Adjacent to Parking)



Green Gutter Section (With Flush Street Curb—No Adjacent Parking)

This option should only be used on streets where no on-street parking is adjacent to the curb, but it can be used where bike infrastructure is adjacent to the curb.



RAIN GARDENS

Rain gardens are large, shallow, vegetated depressions in the landscape. They can be any size or shape, and are often designed to occupy “leftover” spaces along street frontages, plazas, and in situations where street geometries intersect at odd angles, such as areas near intersections on streets with angled parking zones. They are also typically designed to be flat-bottomed without any longitudinal slope in order to maximize storage potential for stormwater.

Rain gardens retain stormwater, thereby attenuating peak flows and overall volume. They can also allow for infiltration, depending on the capacity of the native soil. Although rain gardens can share certain characteristics with swales and planters (they can be designed with vertical curbs or side slopes), they differ from swales in that their primary function is the maximum storage of runoff, not conveyance.

The primary advantage of rain gardens is their versatility in size and shape. Because rain gardens are larger in size, they can potentially cost more than other stormwater facility options, but they also manage correspondingly larger volumes of stormwater. Hence, they can offer a good value. Simple rain garden applications that do not use extensive hardscape or pipe infrastructure can be very cost effective to install.

It is best if rain gardens allow for natural infiltration. However, if infiltration is not possible, rain gardens can also be designed as a flow-through system with an underdrain.

Key Design Considerations

Dimensional Requirements
Minimum length and width to be determined by appropriate sizing of contributing stormwater Drainage Management Area (DMA) and the ability to fit the rain garden between street amenities and utilities.

Stormwater Entry
A 2’ minimum width standard curb cut at the flowline of the street allow runoff to enter the curb extension. Surface grading around the curb cut should freely direct water through the curb cut.

Sediment Forebay
3’ square flat-bottom concrete forebay pad should be placed immediately downstream of the entry curb cut 4” lower than the street gutter grade to allow for sediment to drop out onto the concrete pad before entering the landscape area. Vegetated can also be placed around the concrete pad to act as a natural dam incent sediment and trash particles to settle in the forebay area.

A large rain garden can often fit within existing under-utilized space at street corners.

A beautifully integrated rain garden retrofit in Portland, Oregon helps form this plaza space.

A triangle-shaped rain garden conforms to angled parking configuration. Note that there is extra space allocated to step out of the side vehicle parking space.

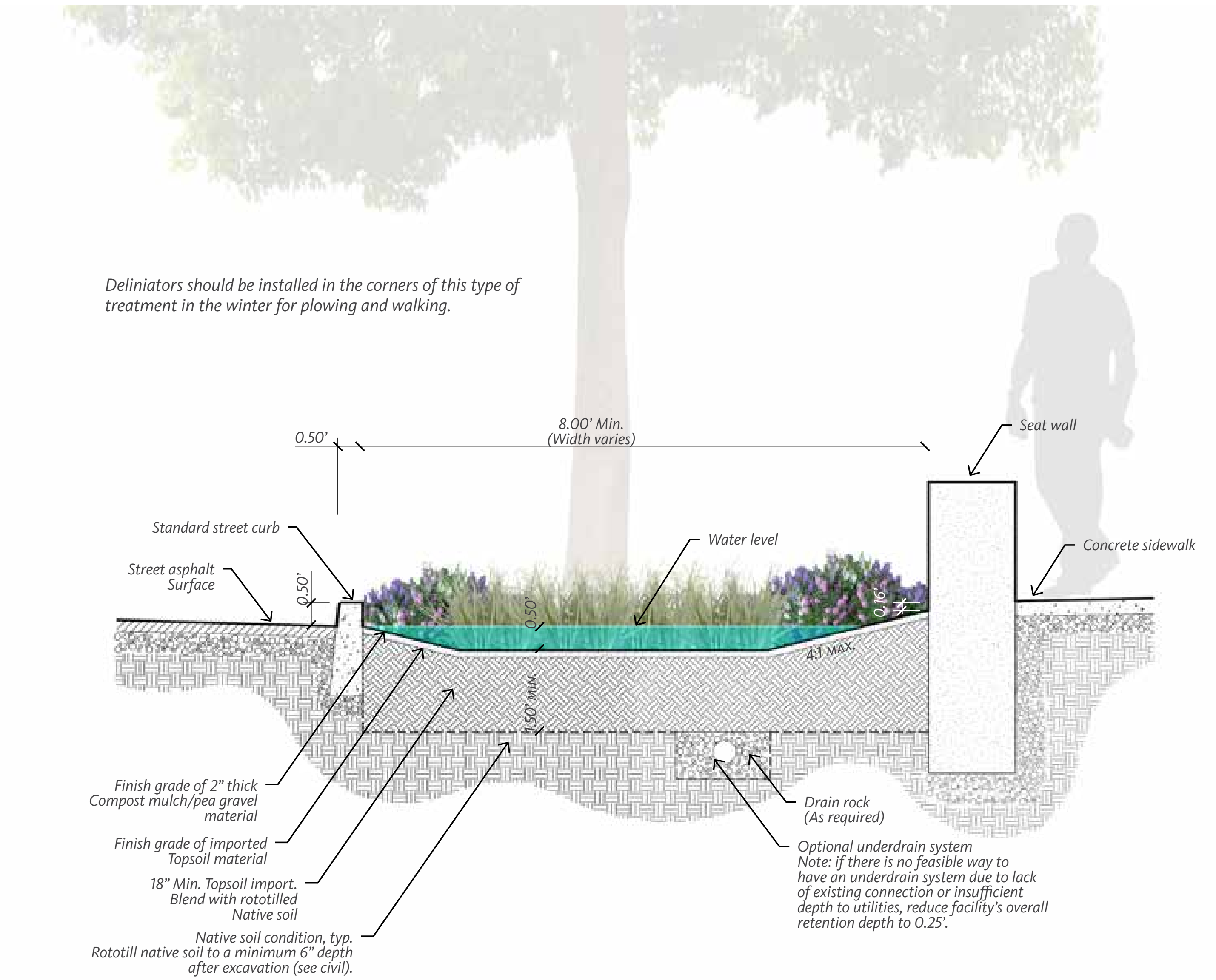
Water Retention Depth

Maximum water retention depth should be 8" of water and can be controlled using check dams and weirs. Rain gardens should have check dams installed for street slopes over 2%. For streets slopes over 5%, the interior of the rain garden should be terraced with check dams and act more as a series of planters.

Grading Considerations

Grade changes directly abutting pedestrian walkways should transition at a maximum 4:1 side slope towards the facility's lowest elevation. Any vertical grade changes more than 7" should require exposed curbs or low-railings to help protect pedestrians from abrupt grade changes. Grade changes from the vehicular side of the rain gardens should also transition at a 4:1 side slope and match the street grade elevation prior to grade transition. In some cases where terracing the grade is desirable, creating a flat-bottom grading condition with respect to the street-side curb can be achieved, but care should be taken to not have an overly deep grading condition.

Rain Garden Section



PERVIOUS PAVERS IN PARKING ZONE (PILOT)

Parking zones are excellent applications for interlocking concrete pervious paver systems. Many interlocking concrete unit pavers are designed specifically for stormwater management applications. They allow water to pass through joint gaps that are filled with small aggregates and infiltrate into a thick gravel subgrade. This system is widely applicable to both small and large paving applications and it offers the flexibility to be repaired because small sections can be removed and replaced. Interlocking concrete unit pavers offer flexibility in color, style, joint configuration, and paving pattern.

It is important to note that selected pervious joint pavers along pedestrian areas must be ADA-compliant and not cause tripping hazards. When installing pervious joint pavers, care should be taken to assure that the base and subgrade is properly constructed to minimize the potential for differential settlement. Regular vacuum cleaning of the paver joints will help prevent clogging and extend the longevity of the system.

Pervious paving within the parking zones of streets can be combined with other curb zone landscape stormwater treatments such as stormwater curb extensions and green gutters to maximize the potential for stormwater management.

Key Design Considerations

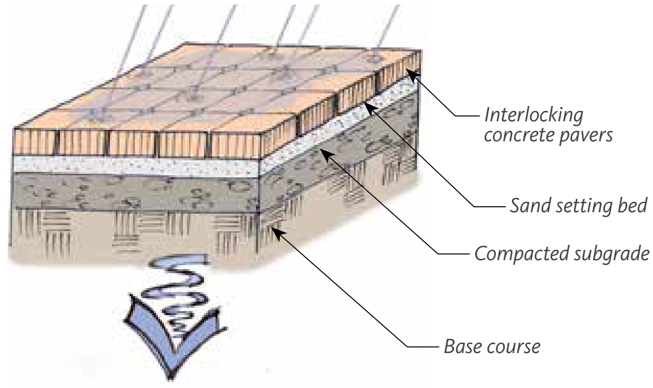
This treatment should be piloted in alleys or on low volume streets before applying this treatment broadly throughout downtown. This treatment may only be applied in consultation with the Department of Public Works until such time it is no longer indicated as a pilot in these standards.

Vehicle Loading Requirements
Pervious paving systems need to maintain H-20 vehicle loading capability.

Maximum Gap Between Pavers
A ½” maximum gap is to be maintained between pavers to be ADA compliant. A ¼" gap is preferred where pedestrians will traverse.

Minimum Gravel Sub-base Depth
A 12” minimum gravel sub-base is necessary under parking zone pervious paving systems.

Edge Conditions
Concrete band is required where pavers meet asphalt edge and granite curb, which typically doesn't incorporate concrete gutter (see photos at right).




A residential street with interlocking concrete pavers within the parking zone.


A urban street with interlocking concrete pavers within the parking zone and tree belt zone.

Pedestrian Zone

PERVIOUS PAVERS IN TREEBELT ZONE

Sidewalk tree belt zones on urban streets are excellent applications for interlocking concrete pervious paver systems. Many interlocking concrete unit pavers are designed specifically for stormwater management applications. They allow water to pass through joint gaps that are filled with small aggregates and infiltrate into a thick gravel subgrade. This system is widely applicable to both small and large paving applications and it offers the flexibility to be repaired because small sections can be removed and replaced. Interlocking concrete unit pavers offer flexibility in color, style, joint configuration, and paving pattern. Along streets that utilize salt in winter conditions, only clay pavers should be used.

It is important to note that selected pervious joint pavers along pedestrian areas must be ADA-compliant and not cause tripping hazards. When installing interlocking concrete pavers, care should be taken to assure that the base and subgrade is properly constructed to minimize the potential for differential settlement. It is important to design the pervious paver system sub-base to allow for the infiltration of stormwater, but also be able to consistently support the weight of occasional emergency and/or heavy duty utility vehicles traversing its surface and not allow pavers to buckle over time. Regular vacuum cleaning of the paver joints will help prevent clogging and extend the longevity of the system. In addition, periodic replenishment of the joints with fill sand/stones will help maintain structural stability over time.

Pervious paving within the tree belt zones of streets can be combined with other sidewalk landscape stormwater treatments such as stormwater planters and tree grate stormwater planters to maximize the potential for stormwater management.

Key Design Considerations

Vehicle Loading Requirements
Pervious paving systems need to maintain H-20 vehicle loading capability.

Maximum Gap Between Pavers
A ¼" gap is preferred where pedestrians will traverse. A ½" maximum gap is to be maintained between pavers to be ADA compliant.

Minimum Gravel Sub-base Depth
A 12" minimum gravel sub-base is necessary under parking zone pervious paving systems. Compact base material to allow for enough structural support, but to also allow for infiltration.

Pervious brick pavers in the tree belt zone on S. Winooski Ave. This example accepts sheet flow from non-pervious sidewalks.

An urban street with a centralized tree belt zone with granite pavers separated by ½" wide joints to capture stormwater runoff.

STORMWATER PLANTERS

Stormwater planters are narrow, flat-bottomed, often rectangular, landscape areas used to treat stormwater runoff. Their most distinguishing feature is that the side slopes typically used in stormwater swales are replaced with vertical side walls. This allows for more storage volume in less space.

There are two types of planters used for stormwater management: infiltration and flow-through planters. Infiltration planters depend on native soil conditions that allow runoff to soak into the underlying soil. Flow-through planters are completely contained systems that only allow runoff to soak through the planter's imported soil bed and then into an underdrain system. Infiltration planters are more desirable because they allow for greater volume reduction and further ease the burden on local storm drain facilities. Flow-through planters should be used where native soil conditions are unfavorable to infiltration, where there is underlying soil contamination, where there is close proximity to older buildings with stone foundations, and/or where the seasonal high water table is within 10 feet of the landscape surface.

For Burlington, stormwater planters can be easily incorporated into retrofit conditions and in places where space is limited primarily in downtown urban conditions. If carefully designed to be in context, they can also work well in residential areas. Stormwater planters can be built to fit between driveways, utilities, existing trees and other site elements. Placement, size, and grading of sidewalk planters varies depending on the width of the sidewalk and the source of the runoff. Stormwater planters can be planted with a simple palette of sedges and/or rushes or a mixture of trees and shrubs. Stormwater planters that primarily support the growth of trees are called tree pits or tree trenches. Because planters have no side slopes and are contained by vertical curbs, it is best to use plants that will grow at least as tall as the planter's walls to help "soften" the edges. Planters can be used in both relatively flat conditions and in steep conditions if they are appropriately terraced.

Stormwater planters can be utilized along streets with or without on-street parking. When being used with on-street parking, careful design should be taken to allow for adequate pedestrian circulation around and beside the stormwater planters. If there is more than 6" of vertical drop in grade from the sidewalk zone, there should be some vertical detection of this condition with either raised curbs or low-railings to alert pedestrians.

An urban street plaza with stormwater planters and metal grates used for frequent pedestrian crossings.

A small stormwater planter with a single curb cut that allows street water to enter/exit. (PILOT)

A urban stormwater planter system that captures street and sidewalk runoff also has notched areas for seating.

Key Design Considerations

Dimensional Requirements
5’ minimum, 10’ maximum, cross section width. Minimum length to be determined by appropriate sizing of contributing stormwater Drainage Management Area (DMA) and the ability to fit the vegetated swale system between driveway locations.

Stormwater Entry
Roadway runoff is **NOT** permitted in sidewalk tree wells, unless implemented as pilot project. Pilot project would require the placement of 2’ minimum width standard curb cuts at the flowline of the street at regular frequencies to allow runoff to enter the vegetated swale. Surface grading around the curb cuts should freely direct water through the curb cut.

Sediment Forebay
If curb cuts are used, 1.5’ square flat-bottom concrete forebay pads should be placed immediately downstream of the entry curb cuts 2” lower than the street gutter grade to allow for sediment to drop out onto the concrete pad before entering the landscape area. Vegetated can also be placed around the concrete pad to act as a natural dam incent sediment and trash particles to settle in the forebay area.

Water Retention Depth
Maximum water retention depth should be 6” of water and can be controlled using check dams and weirs. Vegetated swales should have check dams installed for street slopes over 2%. For streets slopes over 5%, the interior of the vegetated swales should be terraced with check dams and act more as a series of planters.

Grading Considerations
Grade changes directly abutting pedestrian walkways should transition at a maximum 4:1 side slope towards the facility’s lowest elevation. Grade changes from the vehicular side of the curb extension should also transition at a 4:1 side slope and match the street grade elevation prior to grade transition.

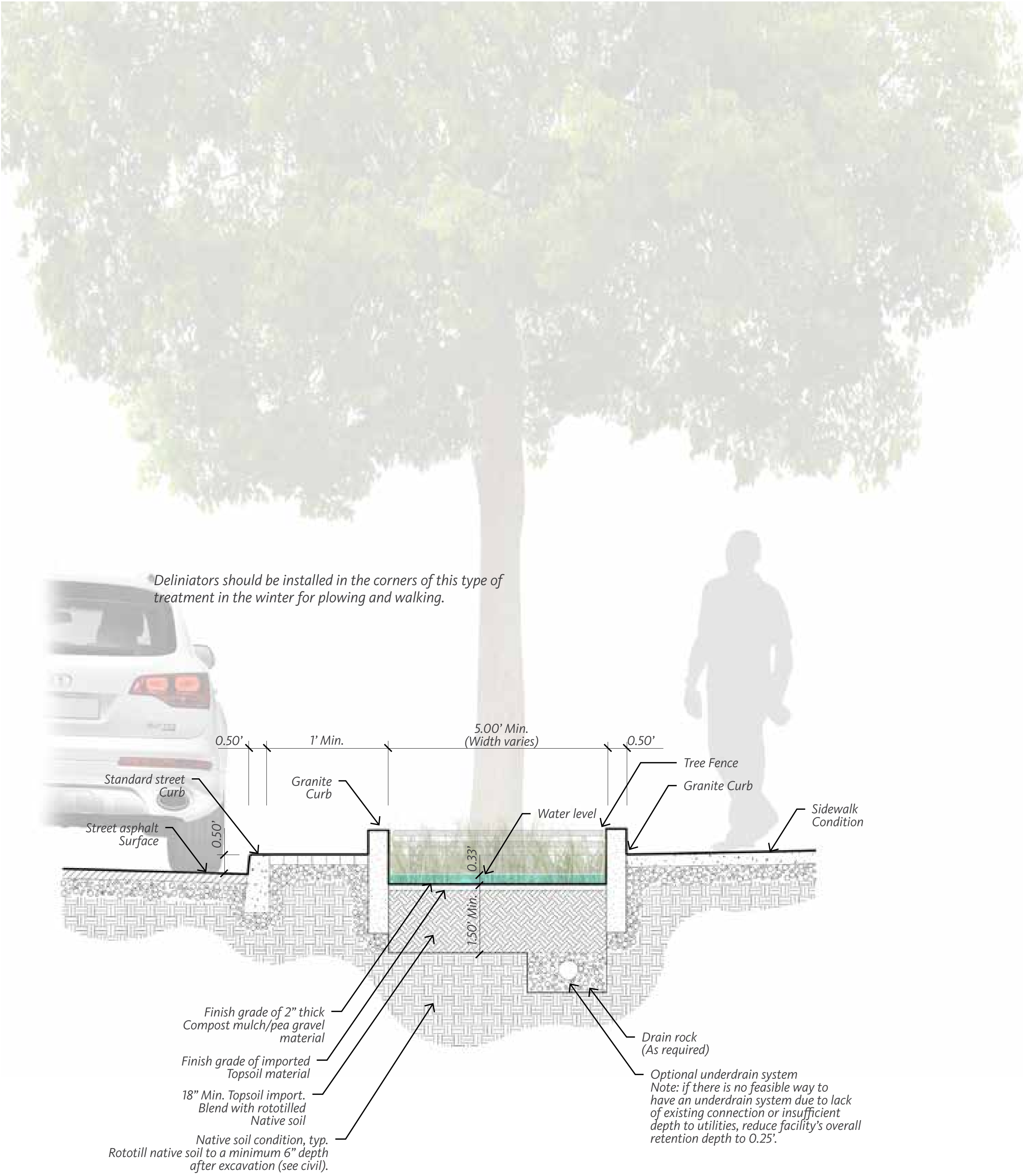
Curbing and Fencing
A barrier is necessary to prevent trash and debris from collecting in these planters, and to ensure pedestrians do not inadvertently step into them. See *"Tree Well Curb & Fence Details" on page 186*.

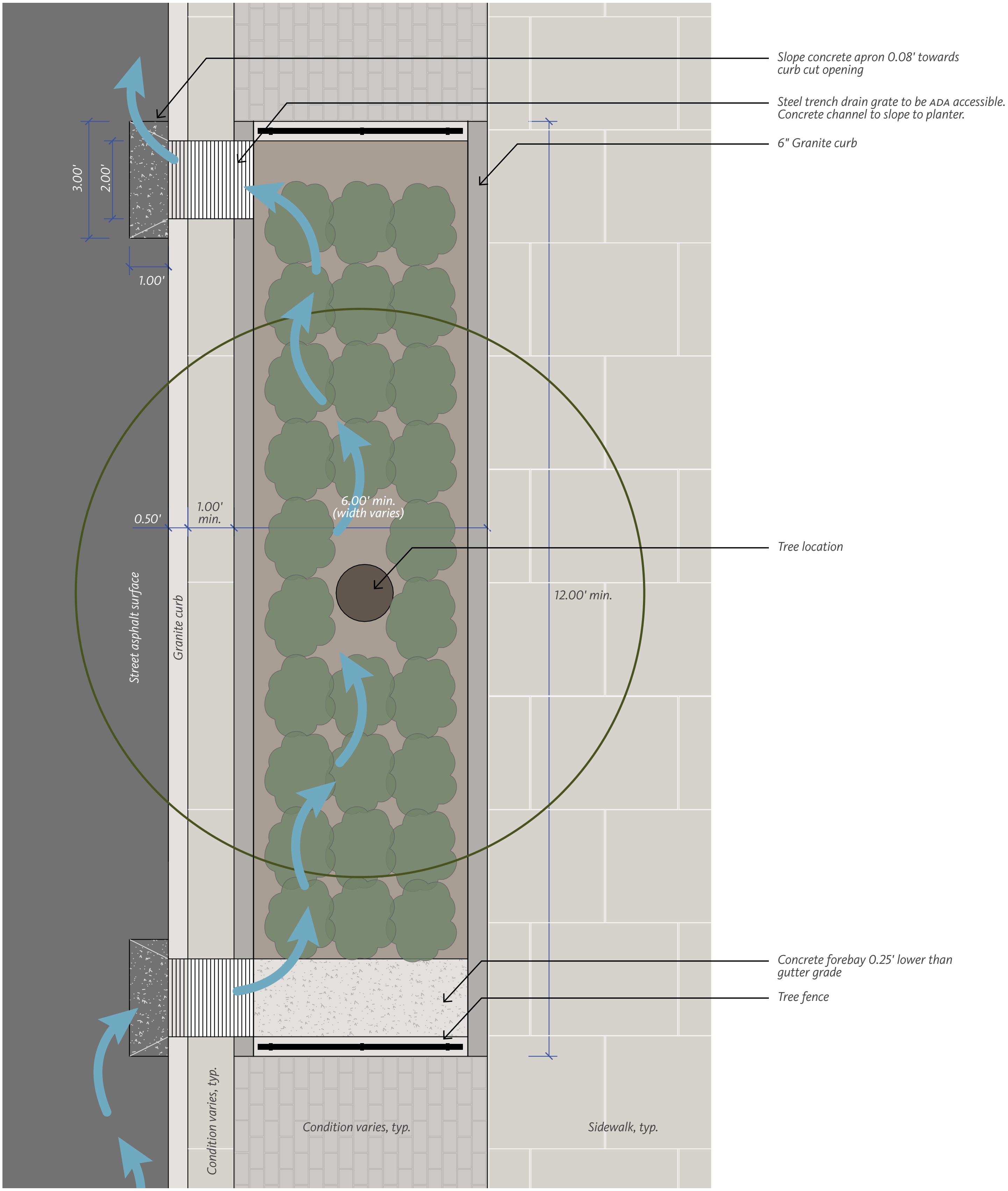
Reference Drawings
See ref. dwg. **SW–05A & B Street Stormwater Planter (No On-Street Parking)** in *Appendix section A-6*.

See ref. dwg. **SW–06A & B Street Stormwater Planter (With On-Street Parking)** in *Appendix section A-6*.

See ref. dwg. **SW–07A & B Tree Pit Planter** in *Appendix section A-6*.

Street Stormwater Planter Section (Adjacent to On-Street Parking) PILOT




Slope concrete apron 0.08' towards curb cut opening
Steel trench drain grate to be ADA accessible. Concrete channel to slope to planter.
6" Granite curb
3.00'
2.00'
1.00'
0.50'
1.00' min.
6.00' min. (width varies)
Tree location
12.00' min.
Street asphalt surface
Granite curb
Concrete forebay 0.25' lower than gutter grade
Tree fence
Condition varies, typ.
Condition varies, typ.
Sidewalk, typ.

VEGETATED SWALES

Vegetated swales are long, narrow landscaped depressions, with defined 4:1 side slopes to transition grade from sidewalk and street surfaces. They are primarily used to convey stormwater runoff and provide water quality treatment, however, they can also be used to infiltrate stormwater runoff using check dams and weirs to control ponding depth. Residential and arterial street conditions that have a long, continuous, an uninterrupted space to support a functioning landscape system are excellent candidate sites for vegetated swales. The recommended improvements to the tree belt type indicate several corridors with a residential street type, where there are no existing street trees or on-street parking. These conditions are very promising to retrofit these areas with vegetated swales.

Vegetated swales are relatively low-cost, simple to construct, and widely accepted as a stormwater management strategy. Vegetated swales can be planted in a diverse plant palette of grasses, sedges, rushes, shrubs, groundcovers and trees.

Key Design Considerations

Dimensional Requirements
4' minimum cross section width. Minimum length to be determined by appropriate sizing of contributing stormwater Drainage Management Area (DMA) and the ability to fit the stormwater planter system between site conditions.

Stormwater Entry
Ideally, stormwater planters can be a curbless application with sheet flow of runoff entering the landscape area. If curbs are required, place 2' minimum width standard curb cuts at the at

An urban arterial vegetated swale retrofit example that accepts runoff through street-side curb cuts.

A vegetated swale incorporated with a bike lane.

A residential vegetated swale on one side of the street.

A residential vegetated swale along a steep street condition.

regular frequencies to allow runoff to enter the stormwater planters. Surface grading around the curb cuts should freely direct water through the curb cut.

Sediment Forebay

If sheet flow is used, no sediment forebay is required. If curb cuts are used, 3' square flat-bottom concrete forebay pads should be placed immediately downstream of the entry curb cuts 2" lower than the street gutter grade to allow for sediment to drop out onto the concrete pad before entering the landscape area. Vegetated can also be placed around the concrete pad to act as a natural dam incent sediment and trash particles to settle in the forebay area.

Water Retention Depth

Maximum water retention depth should be 6" of water and can be controlled using check dams and weirs. Green gutters should have check dams installed for street slopes over 2%. For streets slopes over 5%, the interior of the green gutters should be terraced with check dams and act more as a series of planters.

Grading Considerations

The cross section grades in stormwater planters should be flat with a 2" vertical drop in grade stormwater entry points. In some cases where terracing the grade is desirable, creating a flat-bottom grading condition with respect to the street-side curb can be achieved, but care should be taken to not have an overly deep grading condition.

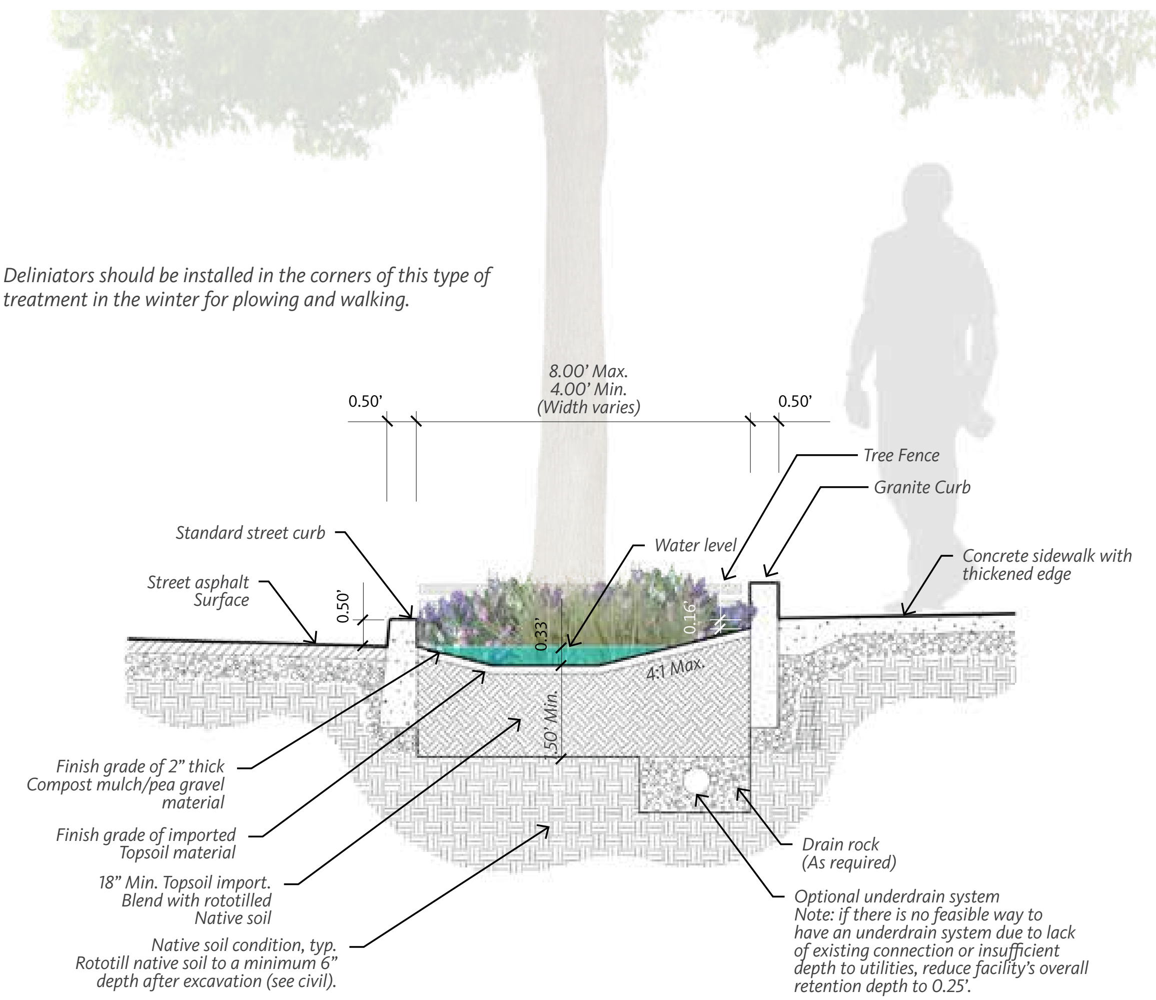
Curbing and Fencing

A curb or fence barrier may be necessary to prevent trash and debris from collecting in these planters, and to ensure pedestrians do not inadvertently step into them. See *"Tree Well Curb & Fence Details" on page 186*.

Reference Drawings

See ref. dwg. **SW–08A & B Vegetated Swale** in *Appendix section A-6*

Vegetated Swale Section



TREE GRATE STORMWATER PLANTERS

In urban downtown areas, such as along Burlington's Main Street, the competition for ground plane landscape space is quite high given the need to maximize usable and unobstructed pedestrian space. However, robust street trees are a vital component to every streetscape to not only provide a comfortable walking condition, but to also capture stormwater runoff. Stormwater planters with street trees can be utilized to capture sidewalk runoff. Installing a metal tree grate between street trees can still accommodate both pedestrian traffic and stormwater management. Tree grates are a common tool in many urban streetscape applications. Unlike typical stormwater planters, tree grate stormwater planters utilize a recessed soil grade to capture, filter, and infiltrate runoff. In some cases, a viable landscape system can also live under the tree grate if the grating gaps allow enough sunlight to reach the vegetation.

Although standard recommendations outlined in this document do not allow street runoff to be captured in tree wells, this system can be implemented under a pilot project condition.

An urban tree belt zone with long, linear tree grates. Image shown may not exactly match specific details of standards proposed in this document. (See p. 307)

A grating system with ¼" gaps that allow enough light penetration to allow sedum to grow beneath the grating. Image shown is for illustrative purposes only. Proposed tree grate gap width will be narrower, per standards. (See p. 307)

Key Design Considerations

Vehicle Loading Requirements
Tree grate stormwater planter systems need to maintain heavy vehicle (H-20 vehicle loading capability).

Maximum Gap Between Grating
A ½" maximum gap is to be maintained between grating to be ADA compliant, preferably ¼" gap where pedestrians will traverse.

Dimensional Requirements
6' minimum cross section width to support healthy tree soil volumes and tree root growth. Minimum length to be determined by appropriate sizing of contributing stormwater Drainage Management Area (DMA) and the ability to fit the stormwater planter system between site conditions.

Stormwater Entry
Ideally, stormwater planters can be a curbless application with sheet flow of runoff entering the tree grate area.

Sediment Forebay
If sheet flow is used, no sediment forebay is required.

Water Retention Depth
Maximum water retention depth should be 6" of water.

Grading Considerations
The cross section grades in tree grate stormwater planters should be flat with a 6" vertical drop in grade stormwater entry points.

Sediment Forebays

DEALING WITH SEDIMENT

In sheet flow situations, sediment and other debris drop out evenly along the length of the stormwater facility. This can reduce the need for frequent removal of sediment from within the facility. However, when curb cuts are used and runoff enters a stormwater facility as concentrated flow, debris will also enter in a concentrated load. The value of using sediment forebays depends highly on how much sediment debris the street typically produces. Some stormwater facilities may not need a sediment forebay at all. Other stormwater facilities, particularly those located on streets that have high traffic loads or substantial leaf drop, would most likely benefit from having a sediment forebay and a regular maintenance schedule to clear debris from it.

Sediment forebays help define a space at the entry of a stormwater facility for sediment and debris to collect and be periodically removed. Providing this space can help reduce maintenance by trapping sediment before it is transported into established landscape areas. The goal of a sediment forebay is to minimize the amount of sediment transported into the landscaped area, not to completely eliminate it.

Ultimately, a sediment forebay should be sized and designed so that it is seamlessly integrated into the landscape area. The design of a sediment forebay can be as simple as leaving a small, shallow-graded, non-planted area right after the entry curb cut. It is recommended that the sediment forebay be paved to minimize erosion and ease the removal of sediment. High density planting located on the downstream side of a sediment forebay can help act as a containment dam for sediment and debris.

A sediment forebay within a stormwater curb extension. (Image source: Nevue Ngan Associates)

A 3 × 3 foot concrete pad is used as a sediment forebay for a large street rain garden. The plant material acts as a dam allowing debris to settle on the pad for regular removal. (Image source: Nevue Ngan Associates)

Check Dams & Weirs

Dealing with Steep Topography

There are many steep slope conditions found along the streets of downtown Burlington that require special design consideration for managing stormwater runoff. Slowing the speed of runoff as it moves downhill helps reduce impacts downstream and mimics natural hydrologic functions. Installing vegetated systems to slow street runoff is the first step, but it may be necessary to also delay the flow of runoff by building structures and terracing the soil grade within these vegetated systems to further slow runoff and incent the water to soak into the ground. These structures are commonly referred to as check dams and weirs. Building terraced stormwater planters and swales help flatten the interior slopes of landscape areas compared to the steepness of a street. Closely-spaced check dams and weirs can then help slow down the flow of water, mimicking a more natural condition. Depending on the underlying soil conditions, some of this water might also infiltrate into the native soils. A geotechnical engineer should be consulted during the design process to evaluate and analyze steep areas for susceptibility to landslides.

Using Check Dams and Weirs

Check dams and weirs are the “speed bumps” of stormwater management. They are designed and strategically placed within a stormwater facility to slow the flow of runoff. Check dams are structures in the landscape that retain stormwater. Weirs are a notch within a checkdam with an adjustable height to allow for varied amounts of stormwater retention. Check dams should retain stormwater to relatively shallow depths, with a maximum ponding depth of 6–8 inches of runoff during storm events.

Both check dams and weirs can be made from a variety of construction materials, such as rock, concrete, metal, wood, or any other durable material. The number and spacing of check dams is largely dependent on the stormwater goal of a project and the particular site conditions. For green street and parking lot applications, slopes greater than 2–4% should have a check dam at least every 25 feet. In steeper conditions, checkdams will need to be placed at a greater frequency (sometimes every 8 feet) and may need to be made from the most durable hardscape materials to withstand the forces of the water.

Check dams may also be placed within swales and planters that have little or no longitudinal slope in order to promote infiltration. This should be done only where soil conditions are conducive to infiltration (Class A or B soils) or where there is an underdrain system installed in the stormwater facility.

A metal weir separates a drop in grade from one stormwater planter to the next. Scuppers along the weir allows for overflow to occur at controlled points.

(Image source: Nevue Ngan Associates)

This adjustable weir can control how much water is to be retained within a rain garden.

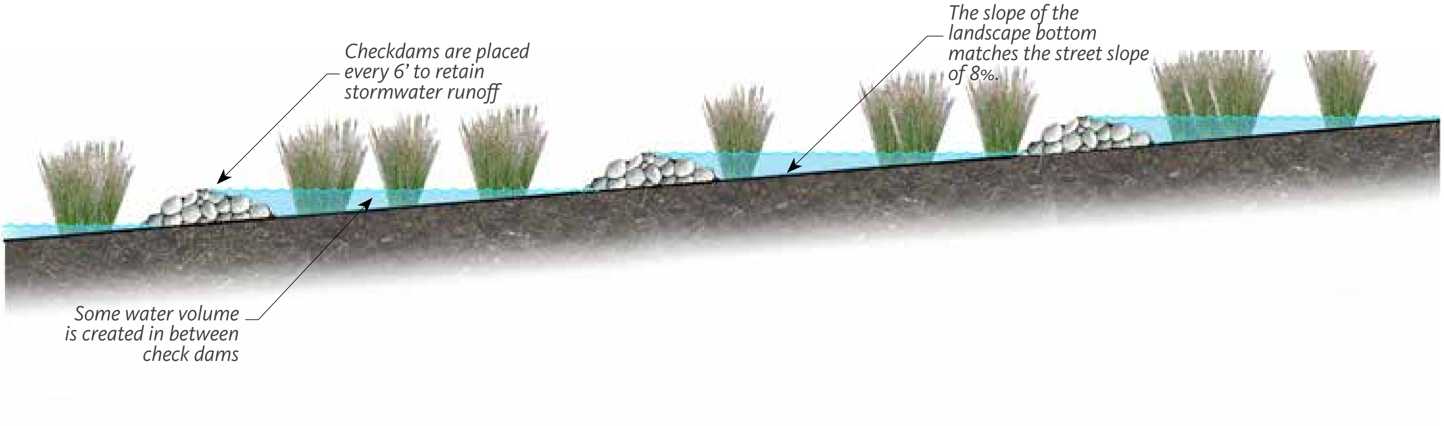
(Image source: Nevue Ngan Associates)

Simple checkdams made of stacked rocks or gravel can be used on gently sloped stormwater facilities.

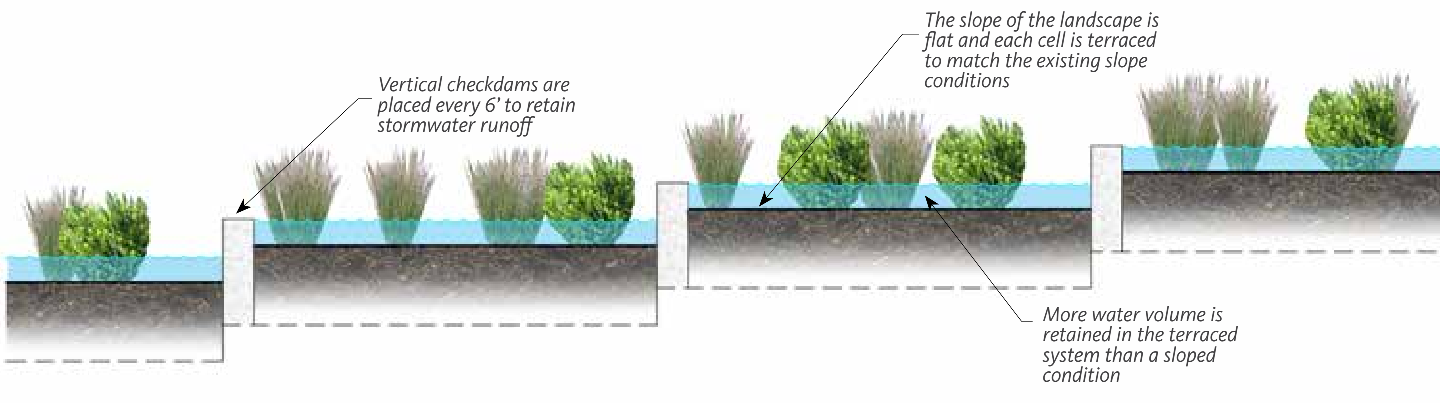
(Image source: Kevin Robert Perry—City of Portland)

A series of wood and concrete checkdams allows for a terracing in grade along a green street project. These checkdams are placed 6 feet on-center to accommodate the street’s 7% grade.

Simple Rock Check Dam Example



Terraced Grade and Vertical Check Dam Example



Capturing Street Runoff

Curb Cuts & Sheet Flows

One of the primary considerations for designing stormwater facilities associated with streets and parking lots is determining how the runoff enters a stormwater facility. There are two primary ways that runoff is directed into stormwater facilities- sheet flow and curb cuts. Sheet flow describes stormwater runoff that enters a stormwater facility evenly distributed on the pavement surface without concentrating flow. Curb cuts allow stormwater to enter a stormwater facility at specific points along a raised curb, thus concentrating runoff both in velocity and volume.

Of the two methods, sheet flow is by far the better design because it mimics the natural flow of water across the landscape, employs a less complicated design, and is less prone to failure. Sheet flow, or "curbless" streets and parking lots, typically employ a concrete band edging that is flush with the stormwater facility and the street/parking lot surface. Having this concrete band provides a clean edge along the more malleable asphalt surface. In addition, the concrete band is easier to fine grade than asphalt in order to direct water into the stormwater facility. Curbless streets do have their concerns, especially during Vermont's winter conditions, because it may be difficult to determine where the street ends and landscape begins when there is prolonged snow accumulation.

Curb cuts along a raised curb system are commonly used to allow water to flow into stormwater facilities, This approach channelizes water flow and can be prone to failure if the curb cut design is poor and/or there is a build up of sediment or debris at the curb cut. If curb cuts are used, they should be carefully designed. Curb cuts should be spaced frequently along the length of the curb to distribute the water flow as evenly as possible within the stormwater facility.

The decision to have curbed or uncurbed streets is typically based on the anticipated type and intensity of vehicular and pedestrian use. In general, the higher the traffic speed and less pedestrian-oriented the street is, the more likely a raised curbed street edge will be required. Conversely, streets that have slower traffic speeds and are more pedestrian-friendly are good candidates for a curbless condition. Even commercial streets with on-street parking can be designed as curbless streets if there is enough right-of-way space and traffic speeds are relatively low.

Curb cuts along stormwater facilities should be as wide as possible to accept flow from along the street or parking lot edge. A flaw in curb cut design is to try to "cover" or create a notched curb cut. These designs often fail because the opening for stormwater runoff is restricted and results in trapped sediment and debris. When a notched curb cut is plugged with debris, it often goes unnoticed. It is recommended that an 24 inch minimum width "open" curb cut be used at entrances to stormwater facilities. On steeper streets, it is a good idea to build a small, low-profile asphalt or concrete berm at each curb cut inlet to guide stormwater flow into the stormwater facility. Without such a measure, runoff can sometimes flow past the curb cut and bypass the stormwater facility during intense storm events. Grated curb cuts, also called trench drains, are often used in street applications to allow water to flow underneath sidewalks. Trench drains for green streets need special design attention and maintenance to assure water will flow into the stormwater facility. Also, grates need to be slip resistant and American Disability Act (ADA) compliant.

Both sheet flow and curb cut systems need to allow for a minimum 3 inch drop in grade between the street/parking lot grade and the finish grade of the stormwater facility. This drop in grade assures that water will freely enter the landscape space even if there is some sediment accumulation.

Catch Basins

Catch basins are subsurface structures that capture stormwater from streets and parking lots through inlet grates. Catch basins are generally installed in a piped stormwater conveyance system and can be used as a pretreatment practice to remove coarse sediment, trash, and debris. They can also serve as temporary spill containment devices for floatables such as oils and greases.

Catch basins that are to be used as a pretreatment practice (i.e. deep sump catch basin) should be isolated from the conveyance system (off-line), having only an outlet pipe which connects to a downstream structure or manhole. The structure should not have any inlet pipes from other structures. A deep sump catch basin should also have a minimum depth of 4 feet below the lowest pipe invert, or four times the diameter of the outlet pipe, whichever is greater.

Catch basin geometry should have sufficient access for inspection and maintenance purposes. Catch basins spacing should not exceed 250 feet and have a drainage area that does not exceed 0.25 acres of impervious area, such as pavement or concrete. They should also be sized to handle flows from 10-year, 24-hour storm event, without interfering with the inlet; and have a maximum depth of flow of 0.35 feet to the catch basin.

Inlet grates to catch basins should be chosen on a case-by-case basis. Considerations that will determine the type of grate necessary for a given catch basin are location, pedestrians or

A standard curb cut allows stormwater runoff to enter a parking lot rain garden. This curb cut has 45 degree chamfered sides. (Image source: Nevue Ngan Associates)

A grated curb cut allows stormwater to pass under a pedestrian egress zone to the stormwater facility. (Image source: Kevin Robert Perry—City of Portland)

This curb cut with side wings retains the side slope soil grade within a rain garden project.

Grated curb cuts conveying street runoff should be at least 18 inches wide, preferably 24 inches wide to adequate handle stormwater flow. (Image source: Nevue Ngan Associates)

This curb cut entry at a stormwater curb extension allows water to enter the landscape along the street's gutter line.

This flush concrete curb allows for even sheet flow to enter a green gutter system. There is about a 3" grade difference between the curb and soil grade.

handicapped traffic, and bicycle traffic. Depending on the terrain at a given location, whether a hilly or flat street, or a parking lot, the hydraulic efficiency of the grate to capture stormwater will be a significant factor. The main considerations for specifying inlet grates are the geometry and the flow-through area of the openings for each individual grate. Additionally, increasing pedestrian and bicycle traffic means that the safety of an inlet grate has become just as important as hydraulic efficiency. Inlet grates may need to be ADA compliant.

The utilization of catch basins will be based on horizontal and vertical site constraints such as existing or proposed utilities, depth to bedrock, or depth to groundwater. Also, the use of debris hoods will require design considerations for cleaning and maintenance of the catch basin.

Catch basins should be located uphill of a curb ramp in order to avoid puddling and freezing in the flattest part of the ramp.

Detention

Underground stormwater retention/detention systems are typically used to store stormwater for a storm sewer conveyance system. Stormwater is detained in an adjacent structure, then discharged at a rate that will not inundate the conveyance system on the downstream end. Alternatively, by using perforated structures installed in a gravel bedding, stormwater detention systems can be used to infiltrate stormwater into surrounding soils, acting as a stormwater treatment practice. Typically, stormwater detention and infiltration systems can be designed for many different shapes, sizes, and materials necessary to meet project needs.

Stormwater detention systems are generally used in new development areas where land availability is limited or there are significant land costs. By using an underground detention system, it could provide an efficient use of the land available and help to reduce cost. These systems can be installed quickly and can be constructed from concrete, steel, or plastic materials; each having advantages and disadvantages. The material type will be dependent on the project requirements.

When designing an underground detention system for infiltration, the main considerations are the soil types and depth of the water table. It is recommended that underground infiltration systems be used in areas with well-drained soils that are conducive to infiltration; and where the water table depth is low enough to allow for groundwater recharge. Generally, the installation of pretreatment practices is recommended to remove sediment and debris that could obstruct perforations. Pretreatment practices could include, but are not limited to, deep sump catch basins, sediment traps, or sand filters.

Subsurface detention systems can provide peak flow control and temporarily store stormwater to be released at a calculated rate. These systems are not typically designed to enhance water quality, however, when combined with other stormwater BMPs, project goals may be met.

Subsurface retention/detention systems have several advantages, including but not limited to: capture and store runoff to reduce post-development peak flows; these systems are better for urbanized areas with space constraints; relatively fast installation time; these systems are estimated last several decades; systems are typically safer with few impacts on aesthetics. Subsurface retention/detention systems also have some disadvantages such as additional excavation is typically required; not primarily designed for water quality enhancement; without proper pre-treatment, infiltration from a retention system may contribute to groundwater contamination; and maintenance and cleaning is more difficult than aboveground systems.

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